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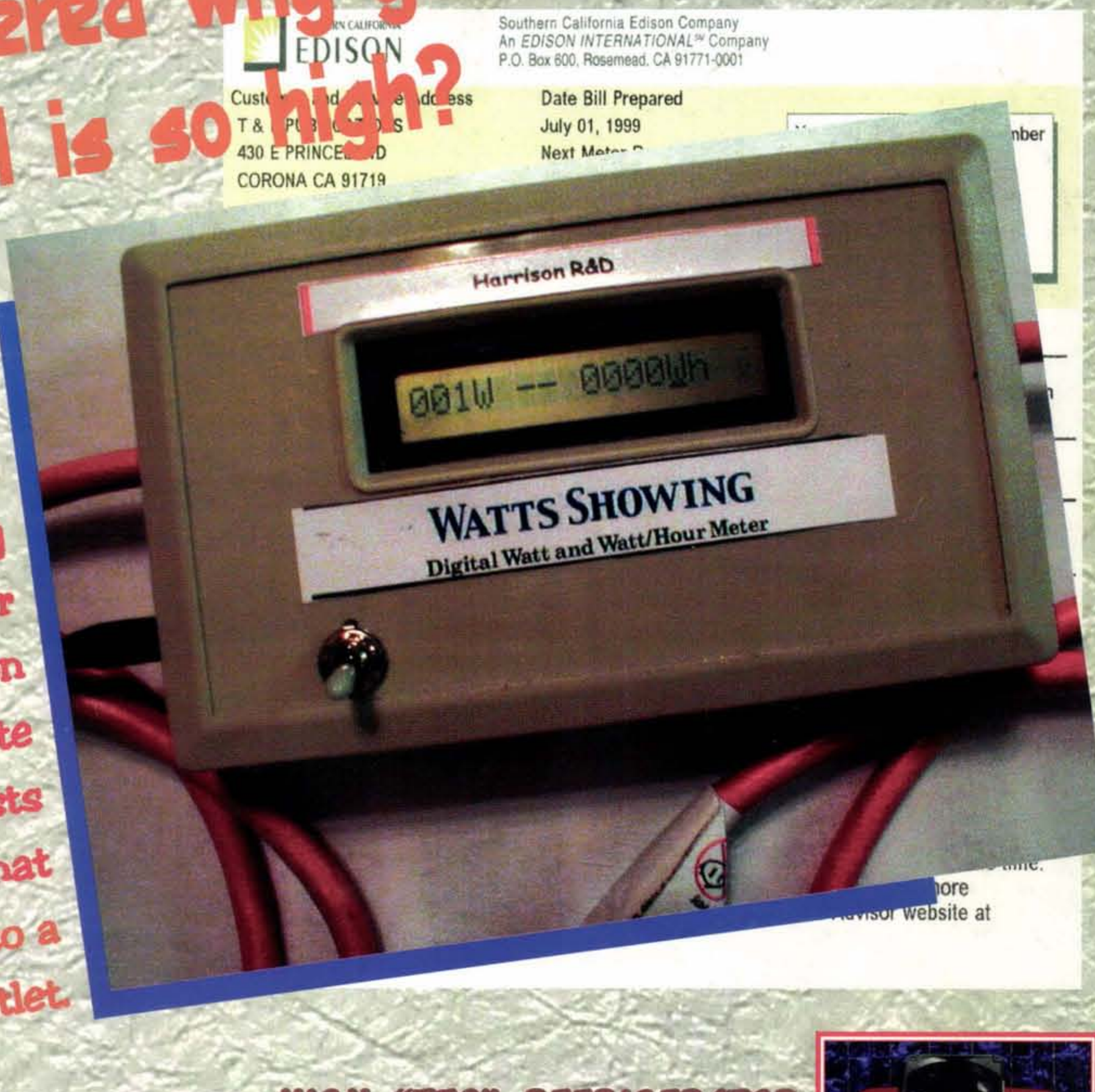

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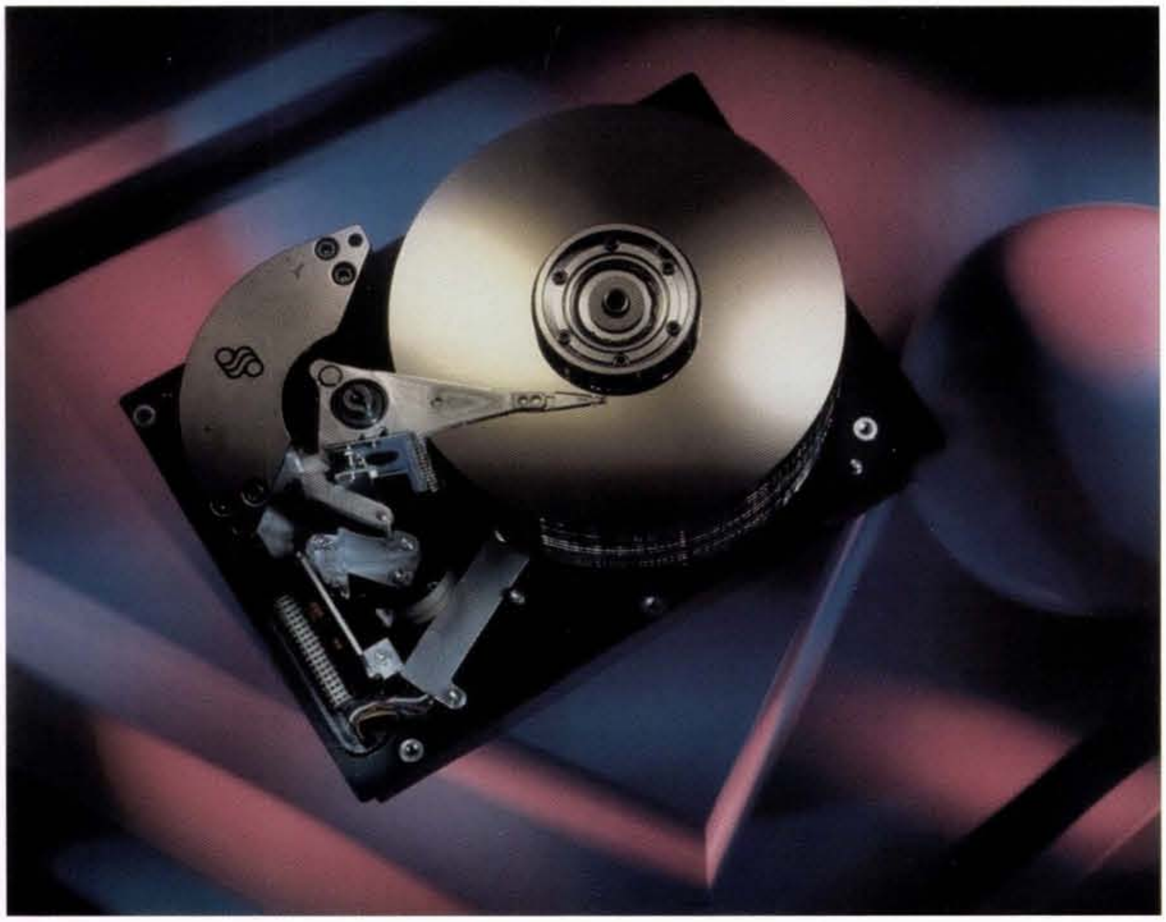

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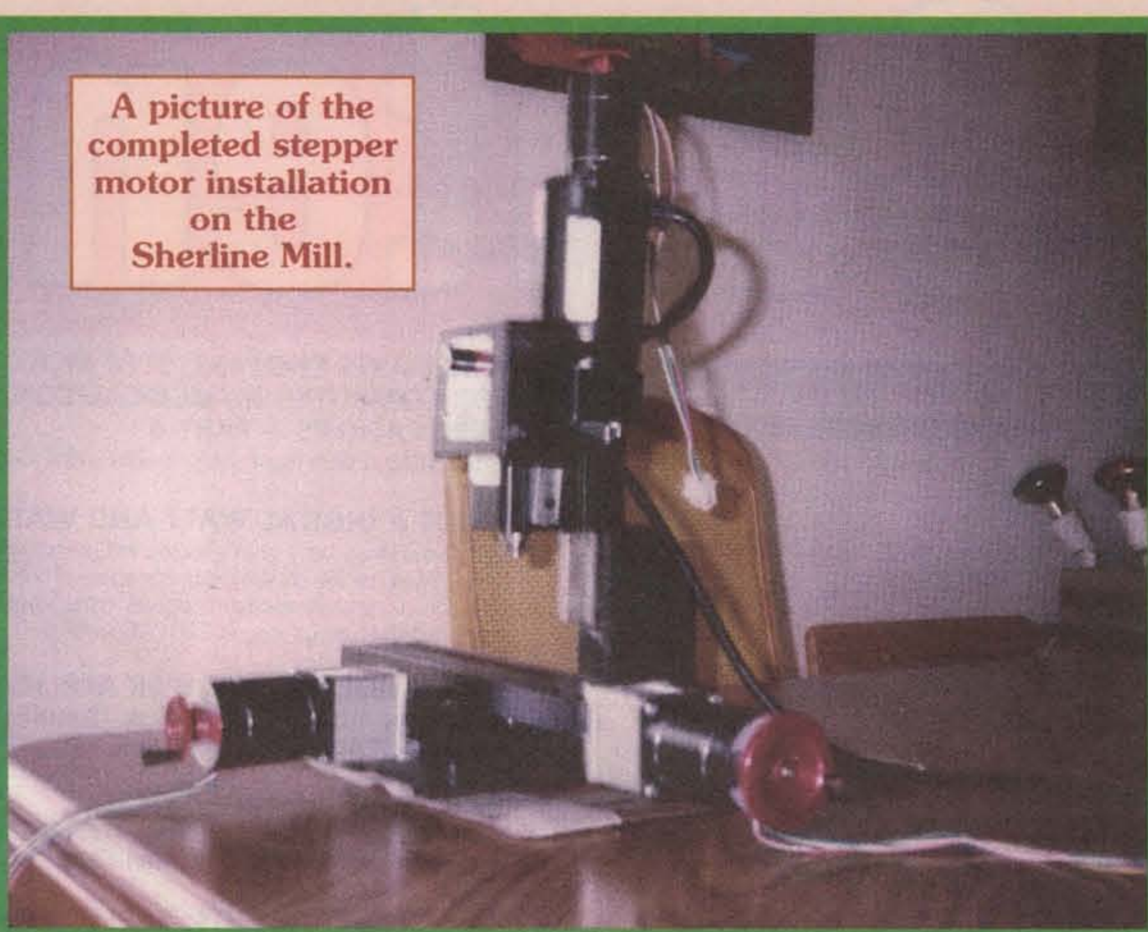
Three-Axis Chopper, Step Motor Controller for Computer Numerical Control (CNC) Applications

Part 4

At Home with CNC — Retrofitting a Desktop Milling Machine for CNC

by Dan Mauch

This article will describe the steps necessary to convert a desktop milling machine to CNC.



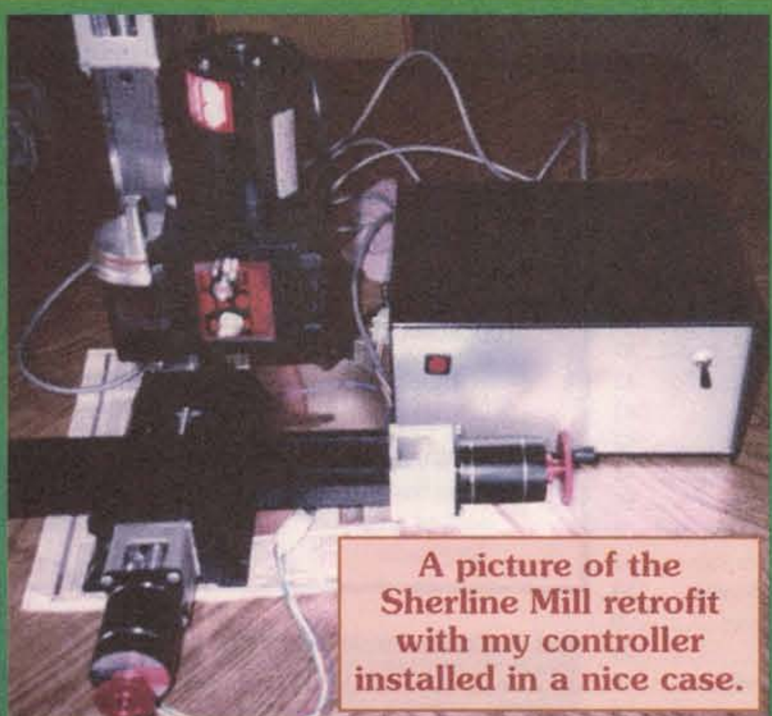
A picture of the completed stepper motor installation on the Sherline Mill.

A desktop milling machine is a great addition to the home shop. It will help make your electronic projects look professional and to accomplish tasks that would be difficult with hand tools. By adding Computer Numerical Controls (CNC) to the milling machine, new horizons will be available to the home shop.

Imagine drilling your printed circuit boards using an automated machine. Think about the project panels you could make if you had a CNC machine to do the work. Think about all the robotic parts you could finally build if you had a machine that could machine the parts that you need. If any of these ideas appeal to you, then a CNC retrofit of a desktop milling machine may be just what you are looking for.

This article will describe the steps necessary to convert a desktop milling machine to CNC. You will find that there are several retrofit kits available from various suppliers. Most of them use similar methods for mounting the stepper motors and connecting the lead screws on the machine to the stepper motors. I found that these retrofit kits tended to be very expensive, so I decided to design and build my own.

The desktop milling machine that I chose to retrofit to CNC was the Sherline Mill model 5000. I selected the Sherline because it is an excellent quality machine capable of doing very good work. Unlike many imported machines, the Sherline has minimum backlash in the lead screw to axis drive nut. This quality makes machining arcs and circles possible.



A picture of the Sherline Mill retrofit with my controller installed in a nice case.

Additionally, there is less chance for tool chatter when you have a close tolerance machine that is well made. The last consideration, but most important, is cost. Here too, the Sherline wins. When all factors are added up, the Sherline lathes and mills are a clear winner in my mind.

If you already have a Sherline mill or lathe, but it is a different model, then the following explanation of the retrofit installation may differ, but the principles should be the same. With that in mind, let's convert our Sherline model 5000 to CNC!

Retrofitting a Sherline is really easy once the mounting plates, extruded spacers, and shaft couplers are in hand. These are available from the source listed elsewhere in this article. The process for installing the parts is similar for the X and the Y axis. The Z axis is slightly different.

The general steps are:

- Remove the X, Y, and Z hand wheels from each axis lead screw.
- Place the mounting plate over the lead screw thrust collar.
- Locate the mounting plate square to the axis.
- Use the mounting plate as a template to scribe and spot the holes to be drilled.
- Remove the mounting plate, then drill and tap.
- Install the mounting plate.
- Slip a thrust bearing over the lead screw.
- Slip a lead screw to the stepper motor coupling onto the lead screw.
- Install the stepper motor on the spacer and secure to the mounting plate
- Check for alignment.

Here are the detailed instructions:

- Remove the X axis (moves left to right) lead screw handle by loosening the Allen set screw.
- Slide the handle off.
- Check that the collar retaining screw is tight. Use an Allen wrench. Do not over tighten.
- Place the X axis mounting plate over the 1" nominal, .997" actual size thrust collar. Do not force it on. It should be a snug fit, but not overly tight.
- Dress the inside of the mounting plate

with 320 grit emery cloth, if necessary, to achieve a snug fit between the mounting plate and the thrust collar.

- Align the edges of the mounting plate so that they are square with the X axis.
- Scribe the mounting holes, then remove the mounting plate to verify that the holes will have a good solid location. Replace the mounting plate when satisfied.
- Use a new #25 high-speed steel drill bit to spot the base to the mounting plate.
- Have a helper watch the drilling operation to make sure that you keep the drill perpendicular to the mounting plate. Drill the two mounting holes approximately ¾" deep clearing the swarf (chips) frequently. Use a lubricant designed for drilling aluminum. Tap Magic is my choice.
- Remove the mounting plate.
- Carefully tap the two holes in the base with a 10-24 starting tap. Use a lubricant designed for aluminum. Tap Magic works great. Follow with a 10-24 bottoming tap.
- Enlarge the two holes for the mounting screws in the mounting plate with a #9 drill bit. This will provide adequate clearance between the 10-24 machine screw threads and the mounting plate.
- Install the mounting plate over the thrust collar. Secure to the base with 10-24 X ½"L machine screws.
- Slip a thrust bearing and two thrust washers over the lead screw shaft. Add a bit of lube to the bearing.
- Slip the shaft coupling over the step motor shaft. Do not tighten the set screws yet.
- Slide four, 10-24 x 2-3/16"L Round Head Machine Screws (RHMS) into the stepper motor mounting flange, through the extruded spacer, and thread the mounting screws into the mounting plate making sure the coupling slides onto the lead screw shaft.
- Reinstall the lead screw handle on the back of the stepper motor. Secure with an Allen wrench.
- Position the coupling so that it bottoms against the thrust collar and thrust bearing assembly. Tighten the coupling set screws using an Allen wrench. Make sure that the inside thrust collar of the lead screw is bottomed on the opposite side of the thrust collar, otherwise excessive backlash will be encountered.
- Test the alignment by rotating the handle, making sure that none of the leads on the stepper motor are shorted together. The axis should turn freely with only the cogging of the stepper motor felt. Adjust as necessary to achieve this alignment.

This completes the X-axis.

The Y axis (front to back) is similar except that the two mounting holes are located at the bottom of the mounting plate.

The Z axis (up and down) is a bit different in that there is only a limited area to drill and tap for the mounting plate holes. The holes in the plate near the center are the correct holes to line up with the Z axis dovetail. Be absolutely sure that you scribe the holes and check how they land on the dovetail slide before reinstalling and drilling.

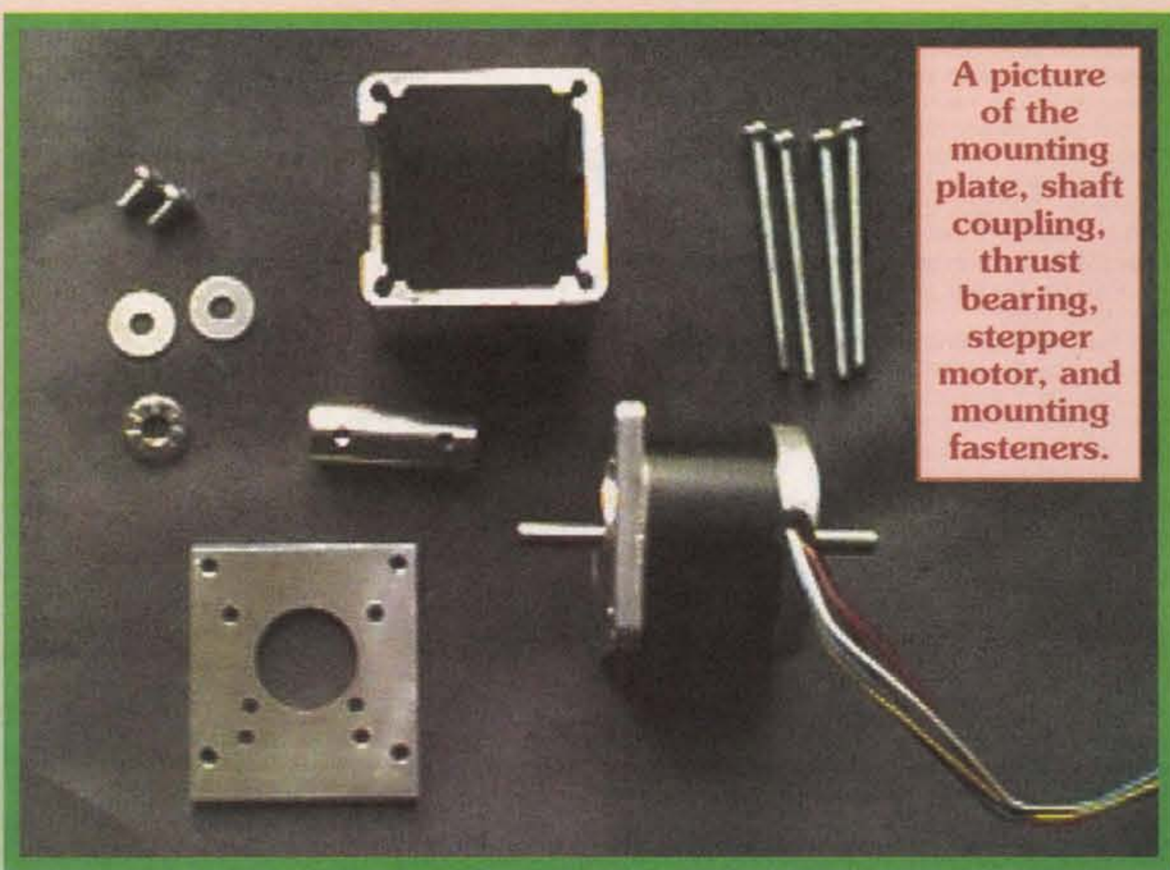
Prerequisites

Before connecting the stepper motors to the controller, verify the following:

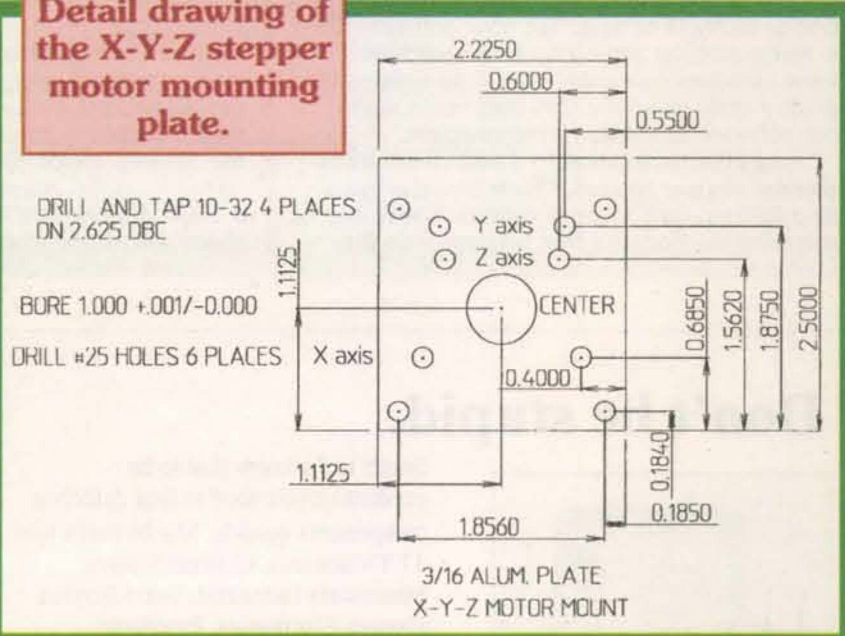
- That the PC is connected to the controller.
- That the controller's Vref was adjusted to the stepper motors installed.
- That the hand wheels on each axis turn the lead screw with no more force than it takes to overcome the cogging of the stepper motor.
- That the set screws on each coupling are tight.

Testing

- With the power off, connect the stepper motors electrically to the controller.
- Boot up your computer and configure the software for



A picture of the mounting plate, shaft coupling, thrust bearing, stepper motor, and mounting fasteners.



Detail drawing of the X-Y-Z stepper motor mounting plate.

your parallel port. Set the parameters used for the Sherline Mill. With the controller set in the half-step mode for each axis, the number of steps per unit should be 8000, thus, a resolution of .000125" per step.

- Measure the backlash and divide the backlash by .000125, thus .002" backlash will be .002/.000125=16 steps. Place that value in the backlash location on the set-up menu.
- Run the G code interpreter program. (Desknc for Dos)
- Turn on the controller.
- Jog the X axis left and right.
- Jog the Y axis front and back.
- Jog the Z axis up and down.
- Adjust the configuration file as needed.
- Enter the command G00X1. The X axis should move rapidly 1.000" in the X positive direction.
- Enter the command G01X0F1. The X axis should move back to the X = 0.000 location at a slow feed rate.
- Accomplish the same on each axis.

Note that the dials will not come back to zero because the backlash compensation will offset the dial locations by the amount of backlash compensation added into the configuration file.

Micro switches to limit the maximum travel for the X, Y, and Z axis should be installed on your first CNC machine. This will help prevent damage to the machine caused by operator error or faulty G coding. See your software files for instruction on setting up limit switches. Home switches can reduce the time needed to set up a task. Read the files that come with your software to set up home switches.

Avoid the temptation to install much more powerful stepper motors. I have heard of guys using 250 oz. inch stepper motors. These are professionals. For your first attempt, use the ~60 oz. inch motors from the source listed. They should reduce the chance of damage to the machine should there be a mistake in your tool path file. The Z axis motor, however, can safely be upgraded to 125 oz. inches. I installed these type motors on the three axes of my machine because I have extensive experience with them.

Troubleshooting

If any axis seems to lack power, check that the configuration file is set up correctly. Ensure that the maximum feed rate is not excessive. Set it so that each axis will accept the G00 (X), (Y), or (Z) commands without any axis losing steps. Adjust as necessary.

If the stepper motors sound fine, then make sure the set screws are securely tightened. Replace the set screws at the first sign that they are rounding off. The stepper creates a lot of vibration. The set screws may come lose in time. After the machine is operating correctly, a drop of locktite in each set screw hole will prevent further loosening of the screws.

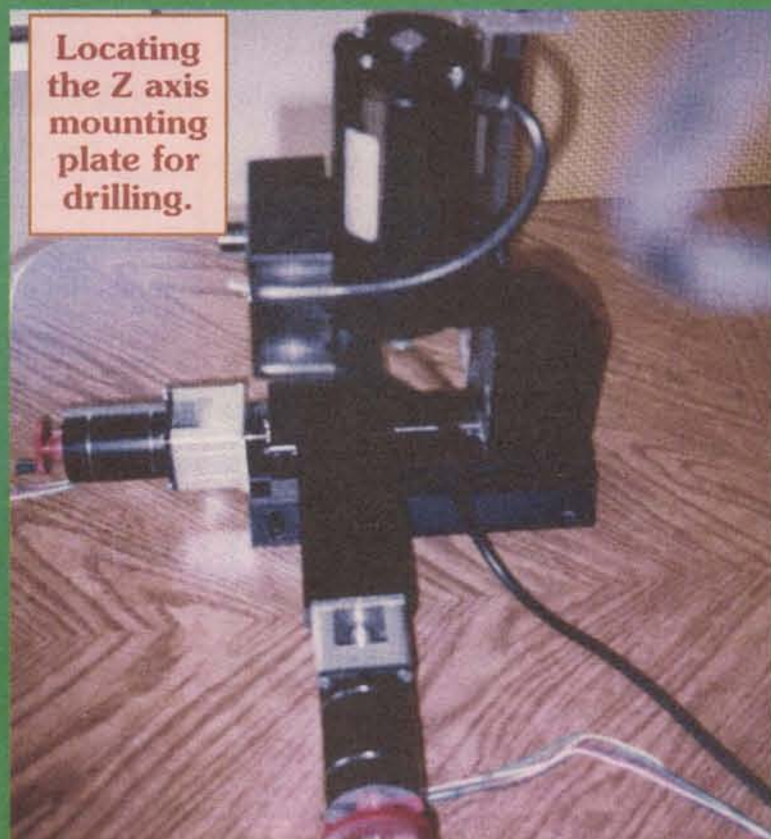
If you notice lost step during one of the arc or circular G code commands, such as G02 or G03, then your feed rate for that particular arc is too fast. Slow the feed rate down during arc and circular moves.

If you continue to lose steps during circular moves after you have reduced the feed rate, then you may be seeing stepper motor resonance. If your controller is in the full-step mode, shift to the half-step mode. Alternatively, a slight drag on the X, Y, Z slides will also eliminate/reduce resonance problems. You can adjust the gibs on each axis accordingly.

Safety

- ***Never let a machine operate unattended.***
- ***Always wear safety glasses when running the machine.***
- ***Keep children away from the area while operating.***
- ***Read, understand, and follow the safety instructions provided with the Sherline Mill, the software, and the controller.***

CNC may be addictive (humor). Once you successfully create your first perfect part, you will be inspired to accomplish even more challenging tasks. That is when CNC becomes addictive. We all have our faults. This would be a great fault to have. This concludes this series of articles. Look for a future article on more advanced projects using the CNC Sherline Mill. If you have any questions, you may E-Mail me at dmauch@seanet.com. **NV**



Locating the Z axis mounting plate for drilling.

SOURCES

Sherline Mill — **Sherline Products**, 170 Navajo St., San Marcos, CA 92069-2593; (Tel) 1-800-541-0735; (Internet) Model 5000 — $500.00; www.sherline.com/sherline

The following are available from **Camtronics, Inc.** — Three-axis, two-amp chopper driver kits are $145.00 plus $9.00 S/H. Dual shaft stepper motors are $25.00 per axis plus $4.00 S/H per motor.

A limited number of three-axis stepper motor mounting kits designed for the Sherline Model 5000 are available for $150.00 plus $6.00 S/H. Hardware kits include the shaft coupling, extruded spacers, mounting plates, fasteners, and thrust bearings.

Send check or money orders to:
Camtronics, Inc.
18230 130th PL N.E.
Bothell, WA 98011-3118

Or send E-Mail to dmauch@seanet.com for additional information.

Desknc for Dos may be obtained from http://www.deskam.com.

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Build a Digital Watt and Watt-Hour Meter

by Dan Harrison

Have you ever wondered why your electric bill is so high? How much electricity does your freezer, blow dryer, or air conditioner consume? Most people really have no idea how much each appliance costs to operate each year.

With the 'Watts Showing™,' a digital watt and watt-hour meter kit you can build, data on electrical power consumption can be accurately measured and operating costs calculated on anything that plugs into a 120VAC outlet.

Virtually every house and most apartments in the US are connected to an AC watt-hour meter that the power company or apartment complex uses to measure the amount of electricity consumed. A watt-hour is the equivalent of consuming one watt of power for one hour, or two watts of power for 30 minutes, or six watts of power for 10 minutes, and so on.

Traditional watt-hour meters are electromechanical devices, which use a small amount of the electrical power going through it to spin a wheel, which drives clock-like meter dials. I'm sure that everyone reading this magazine has seen them. [An interesting thought. Just like a mechanical clock with moving wheels, the power company's watt-hour meter can be inaccurate, too. How long has it been since the calibration on your meter was checked?]

Watts Showing is an all solid-state digital version of the watt and watt-hour meter with an LCD display. Any standard AC power voltage or frequency (90-240VAC, 50/60Hz) can be accommodated, making the Watts Showing useful around the world.

Measuring AC Electrical Power

From elementary circuit theory, we know electrical power is the product of voltage times current, P = I x E. For direct current (DC) circuits, power measurements can be made with a simple voltmeter and ammeter. When we get into complex AC circuits, the measurement is not so simple or straightforward.

To understand power measurement in complex circuits, a review of basic Alternating Current (AC) theory is in order.

The electrical power coming into your home has the shape of a sinewave and a frequency of either 50 or 60Hz, depending on where you live. The period for a 60Hz sinewave is P = 1/60 = 16.67ms. In the US, the standard frequency is 60Hz and that will be used for all calculations in this article.

A sinewave and its characteristics are shown in Figure 1. The amplitude of a sinewave is constantly changing with time, so when we refer to an AC voltage, we need to define whether it's the peak value or the RMS value we're speaking of. The peak value is the most distant displacement from the zero line, either positive or negative in a true sinewave. The Root-Mean-Square, or RMS, value is the value that you would read on an AC voltmeter. The RMS value is always .707 of the peak value for sinewaves. Why .707 times the peak value and not 50% instead?

The reason is that a sinewave completes a full cycle in 360 degrees. In each 90-degree quadrant (4 x 90 = 360), the voltage changes by the delta of Vpeak; quadrant 1 is 0V to Vpeak, quadrant 2 is Vpeak to 0V, quadrant 3 is 0V to -Vpeak, and quadrant 4 is -Vpeak to 0V. Knowing that each quadrant is 90 degrees 'long' in angular displacement, then 50% of the rotation is 45 degrees. If you think that half way through the rotation of each quadrant would be the average, or effective voltage you're right! It's the sin (45 deg.), .707, times the Vpeak that we use for RMS voltage.

RMS is the DC equivalent in terms of calculations for power. In other words, a 115VAC (RMS) source driving a 100-ohm load would produce the same power as a 115VDC source driving a 100-ohm load. For a voltmeter (RMS) reading of 115VAC, the actual peak voltage is 162.6V and the peak-to-peak value is 325.2V.

Example: Assume a trivial case of delivering power to a resistive load like an incandescent light bulb. We assume the bulb is rated at 60 watts with nominal 120VAC power input. Given the formula P = I x V and using a little algebra, we can determine that current (I) equals P/V, which is 0.5amp in the case of a nominal 120VAC source. In the resistive case (P) power, is the product of IRms and VRms.

Figure 2 illustrates the relationship of voltage and current in a resistive circuit. We know from basic circuit theory that when inductance and/or capacitance is added to an AC circuit, the phase relationship between current and voltage changes, making measurement of power consumption more difficult. Now it becomes necessary to sum the instantaneous product of voltage and current over time to calculate actual, or real, power.

When RMS voltage and RMS current are multiplied, it is called Apparent Power. This is what you would get, for example, when you use a clamp-on ammeter to measure air conditioner compressor current and multiply that number by the operating voltage to determine power consumption. The number you calculate is not real power, it's apparent power.

It's critical to understand that power cannot be accurately determined by multiplying RMS current by RMS voltage due to the phase difference that exists in a non-resistive AC circuit. This can best be illustrated by the perfect circuit which only contains an inductor and assumes zero resistance in the wires, see Figure 3a. In a purely inductive circuit, current is said to *lag* the voltage by 90 degrees. The voltage leads the current because it depends on the rate of change of current through the inductor, and inductors resist a change in current flow. This is explained as follows.

At some instant in time, the current will equal zero and will begin to increase in value. When the current is increasing — in the first 90-degree quadrant — the counter electromotive force of the inductor opposes the applied voltage and energy is expended countering this force. During the second 90-degree quadrant, the current begins to decrease from its peak value and voltage is again induced in the inductor, but this time energy is added in the same quantity that was used opposing the voltage. Averaging this power results in a zero net power consumed even though large currents and voltages would be measured!

In the real world, nothing is perfect though, and the electrical resistance of the wires will have the effect of reducing the angle of lag. Let's assume that the inductor has a resistance of 10 ohms and an inductance of 100 Mh. See Figure 3b. The impedance of the inductor at 60Hz is about 38 ohms. To determine current, we find the total impedance

$$Z = \sqrt{R^2 + XL^2} \;=\; \sqrt{10^2 + 38^2} = 39.2\Omega$$

The phase angle is

$$\theta = \frac{X_L}{R} = \frac{38}{10} = 75.25^0$$

The value of the current would be

$$I_t = \frac{V}{Z} = \frac{120V}{39.2} = 3.06A$$

giving an apparent power of 367 watts. Only the power dissipated by the resistance is true power and it is determined by

$P = I^2R = 3.06^2*10 = 93.6W$

or

$P = \cos\theta(EI) = 96.3W.$

Remember, in an inductive circuit, true power is always less than apparent power. The ratio of true power to apparent power is called the Power Factor. In the example shown, the power factor would equal

$\frac{P_{true}}{P_{app}} = .255.$

Watts Showing uses an analog quadrature multiplier, actually a Gilbert Cell derivative, to calculate true power. This circuit continuously produces the product of instantaneous voltage and current.

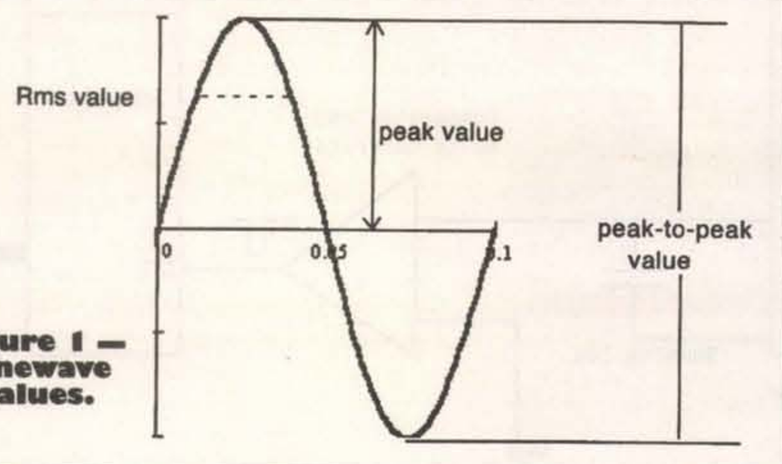


Figure 1 — Sinewave values.

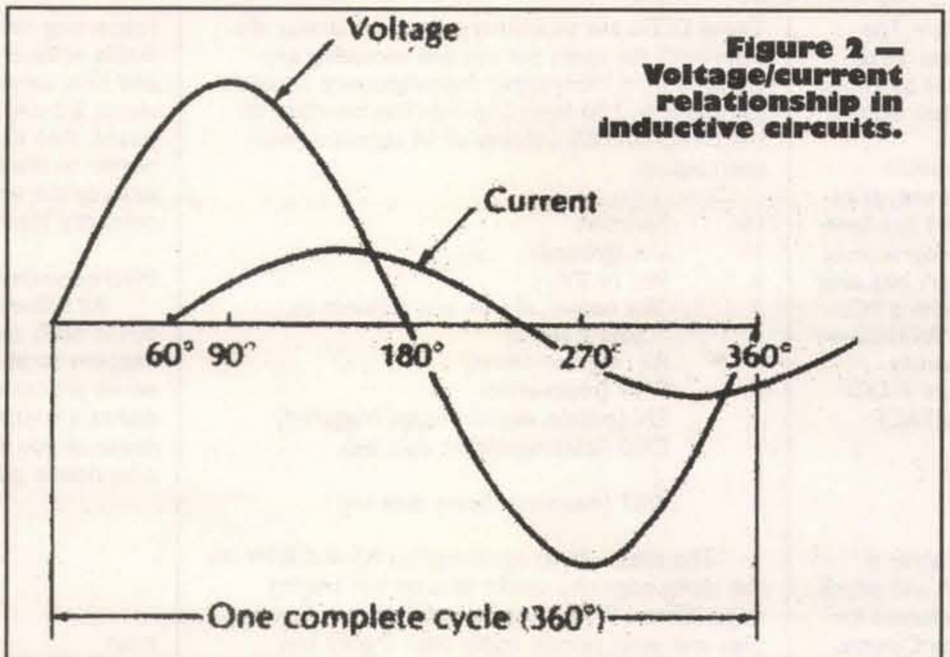
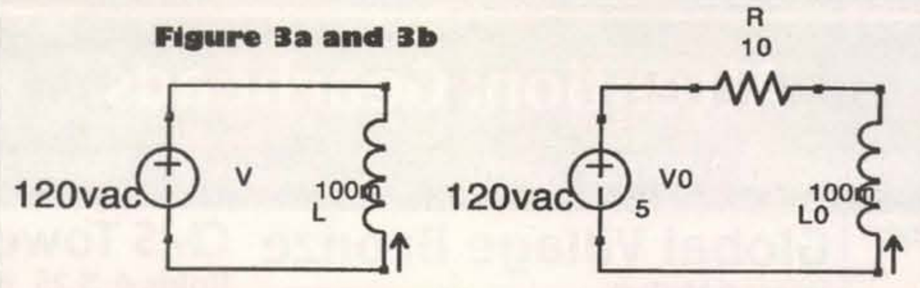


Figure 2 — Voltage/current relationship in inductive circuits.

Figure 3a and 3b



How It Works

The Watts Showing's four main functional blocks are (Figure 4): the optically-isolated AC current and voltage measurement, the quadrature multiplier and summer circuit, the MC68HC705P6 microprocessor, and the LCD display. All four blocks are contained on two circuit boards and housed in a single assembly.

Optically-Isolated AC Current and Voltage Measurement

Refer to the schematic in Figure 5 for the following description. The current and voltage measurement is composed of R1, POT1, Shunt1, and half of U1 (the LEDs). When an AC voltage is applied to the AC input terminals, current flows through either the D1-D3 pair or the D2-D4 pair, depending on the polarity of the voltage. In the no-load case, current flow through all diodes is equal since no voltage is dropped across the shunt, S1. When a load is applied to the AC output, there is a voltage drop across the shunt and slightly less current will flow in D3 and D4 than D1 and D2. The decrease in current flow makes a small change in the light output also. The amount of light output is therefore dependent on both voltage and current (remember that the product of voltage and current is power) at any given time.

```
*************************************************************
* put the LCD cursor in the position specified by
* the contents of ACC
* lcd map 80 81 82 83 84 85 86 87 C0 C1 C2 C3 C4 C5 C6 C7
*
*************************************************************
put_cursor        ;acc=cursor position 0-15
        add    #$80      ;add offset to get address
        cmp    #$88      ;if >88 then add 38h
        blo    do_cursor
        add    #$38
do_cursor
        jsr put_ctrl     ;write character address to LCD control reg.
        rts
```

Listing 1. Put_Cursor

The 500k ohm pot (Pot2) in series with R1, is used to control the bias current through the LEDs in the optocoupler. This bias current sets the rate of discharge of C1, which determines the scaling factor of the watt meter. As the voltage across the shunt increases, it results in a lower voltage across D3, D4, Pot2, and R1. This means less current flow, and lower light output as the power being measured increases. For 220-240VAC operation, R1 and POT1 values must be changed. I've never operated this circuit above 120VAC so, while it should work, I can't say exactly what value resistors will be needed to keep the watt measurement correct.

Quadrature Multiplier and Summing Circuit

The multiplier and summer are made up of all the components inside the dashed block on the schematic. The transistors in U3 form two stacked differential amplifiers, in a modified Gilbert Cell arrangement. The output is proportional to the difference in light output from the LEDs, which we remember is a product of voltage and current (power). This is fed into C1 where it accumulates (sums).

When the voltage on C1 goes below the threshold set by Pot1 (approximately 0.4V, depending on capacitor and resistor tolerances), the output of U2A, pin 1, goes high. This, in turn, takes the inverting input of U2b to a high state, forcing the output, pin 7, to go low. This results in Q1 being turned on which charges the capacitor, C1 through R2.

When the voltage on C1 again crosses the threshold going positive, set by Pot1, U2a will switch back to a low output, driving U2b back to a high output and turning off Q1 which stops charging C1. The values shown will produce a 1-pulse/joule, which is 1Hz/watt. The output pulse width is set to approximately 400uS.

This configuration allows a full-scale measurement of greater than 1,000 watts. One thing to keep in mind about this circuit is the stacked differential amplifiers are extremely sensitive and must be precisely balanced in terms of gain across the four transistors. The gain, or Beta, of a transistor will vary with temperature. So long as all transistors are at the same temperature, the temperature coefficient of the copper shunt helps to cancel out a change in transistor gain as temperature changes. Where you can run into a problem is when a temperature gradient exists across OPT1 and not all transistors are the same temperature. This condition results in erroneous readings and makes it impossible to calibrate. Believe me, I learned this the hard way. Always keep OPT1 away from air currents or heat sources when calibrating.

The MC68HC705P6

As is true with all microcontrollers, there are two parts to this story: hardware and software. First, a discussion of the hardware configuration will be presented, followed by a description of the software that makes it all work.

Microcontroller Hardware

The Motorola MC68HC705P6 is an EPROM version of the MC68HC05P6 microcontroller. It is a low-cost combination of a generic 68HC05 CPU with a 16-bit timer, 176 bytes RAM, 4672 bytes EPROM, and 21 general-purpose I/O lines. A block diagram is shown in Figure 6.

The output pulses from the quadrature multiplier and summing circuit are input to the interrupt pin on the microprocessor. The processor can use this to count the number of pulses and, because it's on an interrupt, the counting process can occur in the background without constant attention from the main program. The interrupt pin must be programmed to be edge-sensitive rather than level-sensitive. Since the pulses generated by the summing circuit are 400uS wide, a level sensitive interrupt will cause the processor to be interrupted many times during the pulse.

The clock generation consists of a 4.00MHz crystal, two 22pF caps, and an 8.2 meg resistor. It's important to include R3 in the clock circuit if you're building this from scratch. This small amount of load helps to get the internal oscillator started; without it you may have trouble getting the processor to operate. The same is true for the Power On Reset circuit (POR), consisting of C6 and R13. The power on reset must be long enough for the crystal and power supply to stabilize. The

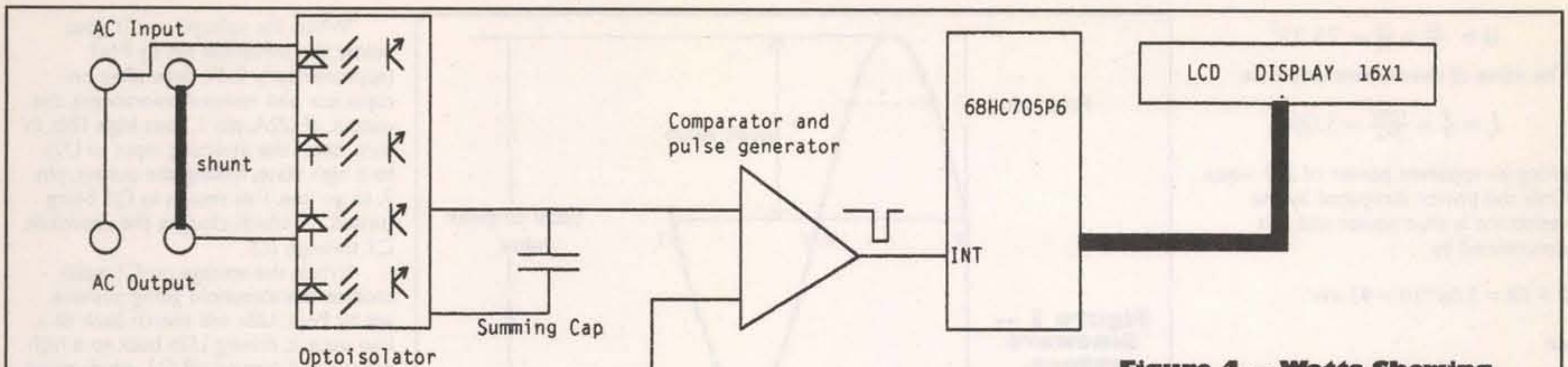


Figure 4 — Watts Showing block diagram.

values shown work well over temperature. The LCD interface is straightforward and uses 11 of the processor's general-purpose I/O lines to implement the data/control path. The serial data output PC0 is for serial data out.

Since the MC68HC705P6 has no built-in UART, and we want this design to be as cost-effective as possible, a "bit-banged" serial port has been implemented in software. This port is programmed to be 9600 baud, eight data bits, two start bits, and no parity. If you want to use this port with a PC, the interface needs to be converted to RS232C or RS422, whichever suits your needs. A sample RS232 interface circuit is shown in Figure 7. DO NOT CONNECT TO AN RS232 INTERFACE WITHOUT THE PROPER CIRCUIT.

LCD Interface

A 16-character-by-one-row LCD display is interfaced to the processor using portA and portB through J1, a 14-pin header. The LCD selected for the interface is a DMC-16117A made by Optrex. These LCDs are an industry standard; similar displays with the exact pin out and mounting are available from many other manufacturers. It sells for about $12.00 from Digi-Key. The interface to the DMC-16117A consists of 14 signals, as outlined below.

Pin	Function
1	Vss (ground)
2	Vcc (+ 5V)
3	Vee (wiper of a 5k pot connect to pins 1 and 2)
4	RS (register select)
5	R/W (read/write)
6	EN (enable, negative-edge triggered)
7	DB0 (least-significant data bit)
|	|
4	DB7 (most-significant data bit)

The enable (EN) signal latches RS and R/W on the rising edge and clocks data on the trailing edge. RS and R/W must be stable before E goes high and must remain stable until E goes low (observing set-up and hold times). Data must be stable while E goes low (again, observing set-up and hold times). Power consumption should be about 2-3mA. If you're building this without the PC board, then care should be taken when connecting power to the LCD. Reversing +5V and GND will destroy the unit. Read your data sheet carefully to correctly identify pins 1 and 2.

Microcontroller Software

All software for the Watts Showing was written in 6805 assembly language. Assembly language happens to be my language of choice for the '05 series processors. At least one software company makes a limited 'C' compiler for this processor for those of you who prefer 'C.' The software overview is outlined in the following pseudo-code:

```
        Power-on Reset
        Initialize processor I/O, timers,
          and A/D
        Initialize LCD display
main    Print start-up message
```

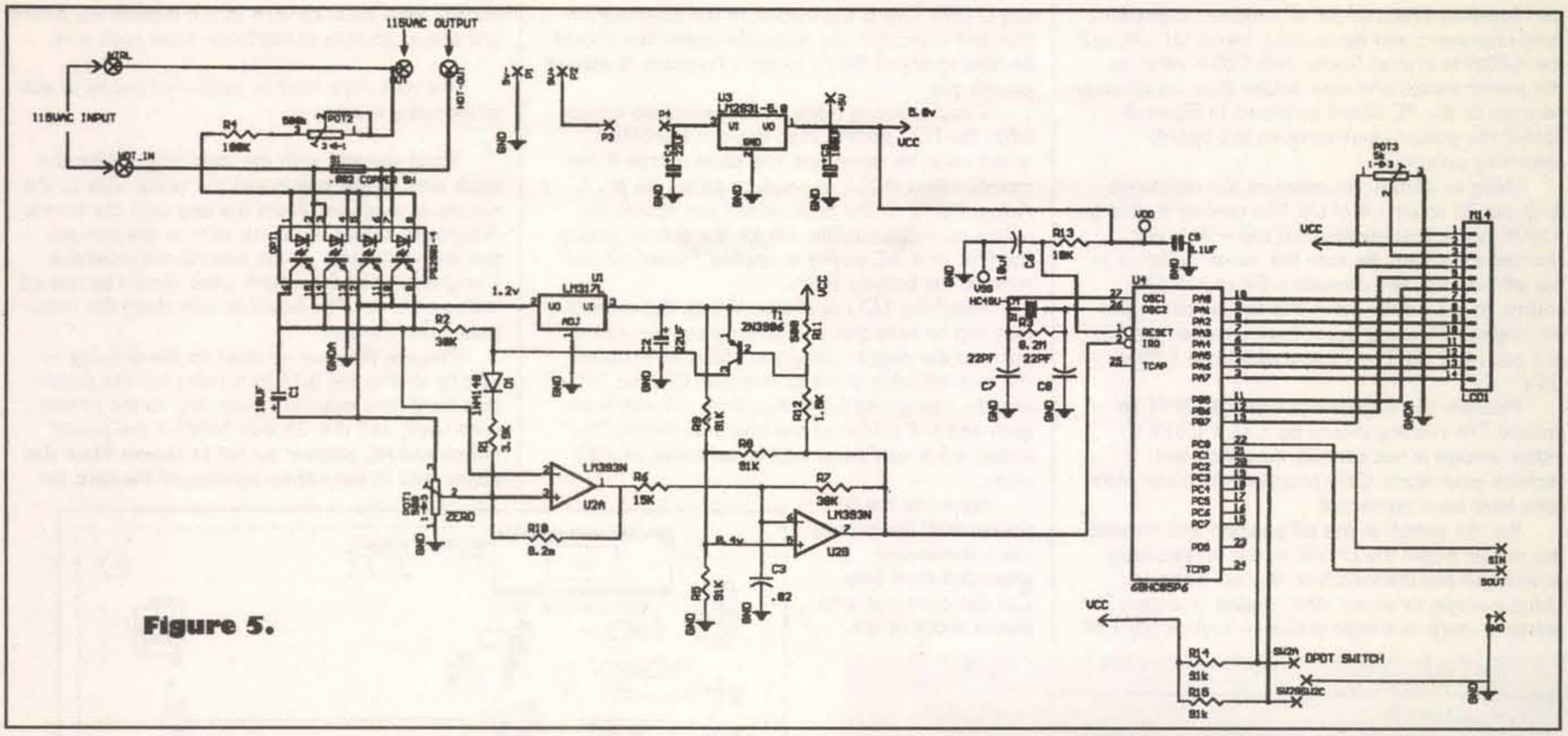


Figure 5.

Start clock
One_second_loop
Wait on clock for 10 "tics"
(One second total time)
Get accumulated one-watt/
second
pulses
Write to display
Add to accumulated watt/
seconds
Convert to watt hours
Write to display
Output watts and watt-hours
to serial port
branch to main

This is a simple structure and programmers should always strive to keep program structures simple. When the program structure is too complex, then the structure should be decomposed to keep each element of your design simple.

LCD I/F Routines

The following LCD initialization was taken from the Optrex LCD data sheet.

Initialization:
set RS and R/W to logic 0
data = 38h for 4ms
data = 0fh for 500ns
data = 38h for 4ms
data = 01h for 500ns
data = 38h for 4ms
data = 06h for 500ns

The display should be cleared with the cursor in the far left position. To send characters to the display, set 'RS' to logic '1' then send the ASCII code for the character. The cursor will automatically increment to the next position, but only for the first eight locations. This is because the 16x1 uses the following memory map:

80:81:82:83:84:85:86:87:C0:C1:C2:C3:C4:C5:C6:C7

The cursor starts out on address 80, increments to 81,82,83. etc. When the cursor is in position 87, it will increment to 88, not C0. So you must keep track of the current cursor position in software and change the internal character address for positions 9-16. Listing 1 is an example of this function. Routines for writing data and control words to the LCD are PUT_DATA and PUT_CTRL. For the control words, the app note instructs us to perform the following sequence:

1. Set R/W = 0 to write to the LCD.
2. Set RS = 0, for an instruction byte.
3. Place data on DB0-DB7.
4. Toggle EN (low-high-low).

Data is latched on the falling edge of EN. Two types of control instructions require extra delay time between the writing of the command and writing data to be displayed. The DMC-16207 supports the instructions shown in Listing 2. These routines were taken from the Motorola HC05 Applications guide. These are the same routines that are used in the Watts Showing.

Timer Routines

Obviously, a watt hour accumulation cannot be accurately made without an internal clock. For the digital watt meter, we use a clock that 'ticks' at 10Hz, for a resolution of 0.1sec. This is accomplished by utilizing the internal 16-bit programmable timer of the 68HC705. A complete description of this timer is found in the MC68HC705P6 data book and the Motorola HC05 applications guide, both available from Motorola. Listing 3 demonstrates how to set up a 100mS loop for timekeeping. The basic form of this routine is taken from the HC05 applications guide.

Building and Testing the Watts Showing

I like the build a little, test a little approach, starting with the printed circuit board. Install and solder all the IC sockets, observing the proper

pin1 location. Next, solder all resistors, capacitors, potentiometers, and diode, CR1. Install U1, U2, and the 4.00MHz crystal. Solder two 22GA wires to the power switch and then solder their unconnected ends to the PC board as shown in Figure 8. Solder the power input wires to the board, observing polarity.

Using an ohmmeter, measure the resistance form pin 28 to pin 14 of U4. The reading should be >100K ohms. This verifies that the +5V is not shorted to ground. Be sure the on-off switch is in the off position, and connect a 6V to 12V DC source to the power input. Put the switch in the on position. Measure the voltage between pin 28 and pin 14 of U4. The voltage should be 5.0V ± .25V.

Measure the voltage from pin 10, OPT1 to ground. The reading should be 1.22 ± 0.05V. If either voltage is not correct, then stop and recheck your work. Only proceed when any problems have been corrected.

Put the switch in the off position and remove the power. Install the LM393 in the socket, apply power, and put the switch to the 'on' position. Using a scope, or some other means to detect fast pulses — such as a logic probe — look at pin 7 of the LM393. This is the output of the summing circuit and interrupts the microcontroller. You should be able to adjust POT2 to get a constant hi voltage on this pin.

If you're seeing many 400uS pulses no matter what the POT setting, then there is a problem which must be corrected. The same is true if you cannot adjust POT2 to produce pulses on pin 7. Adjust POT2 to the point which just causes the pulses to disappear. This will be the default setting the first time AC power is applied. Power off and remove the battery again.

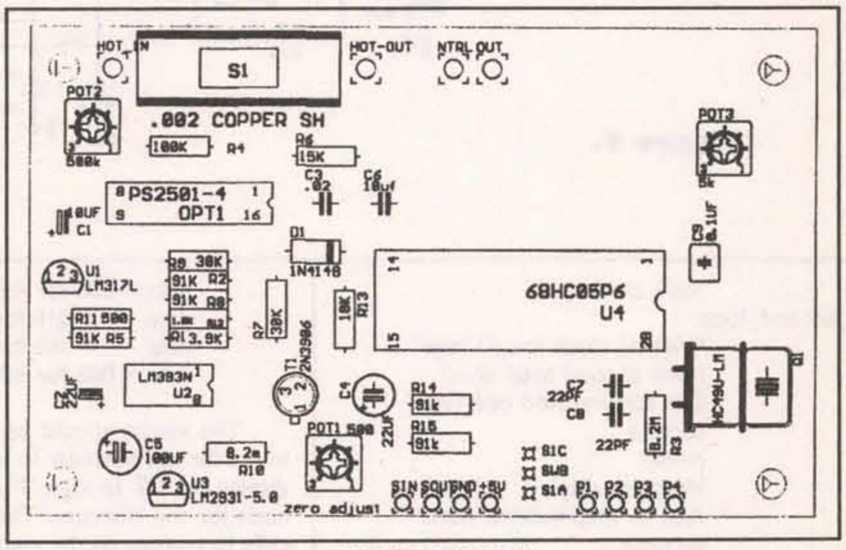
Install the LCD as shown. Watch the orientation and be sure that it is level across the entire plane of the display. Using the 16GA wire, make the two milliohm shunt as directed. Cut the 16GA wire to a length of 6.3 inches. Strip .25 inch from each end and solder to the board as shown. This makes a 5.8 inch shunt with a resistance of .002 ohms.

Now add the AC power cord. Be sure to use a three-wire grounded cord only. Cut the cord into two pieces about in the middle. Strip back 2.5 inch of the outside insulation and about .25 inch of insulation from each wire.

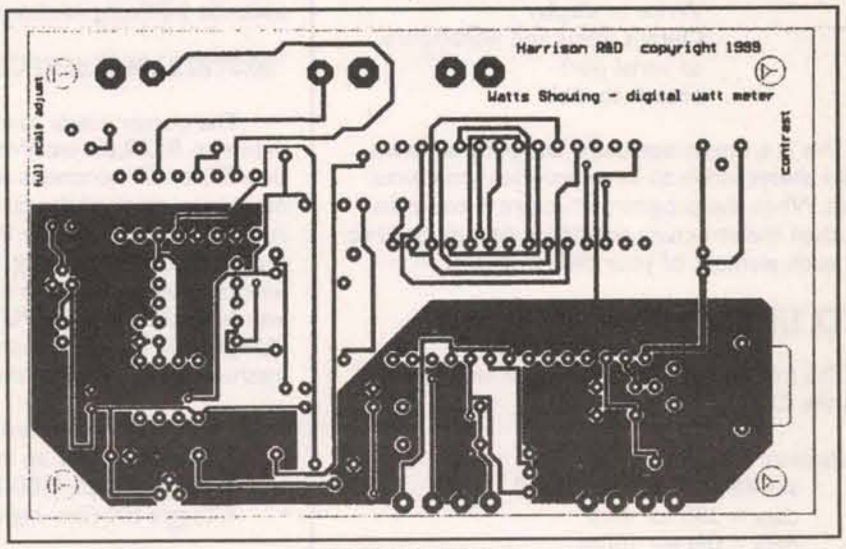
The next steps must be performed exactly as stated for safety reasons.

From the end with the male plug, solder the black wire to the hot-in and the white wire to the neutral-in locations. From the end with the female receptacle, solder the black wire to the hot-out and the white wire to the neutral-out locations. The green wires from both sides should be spliced with a wire nut. The board is now ready for installation into the case.

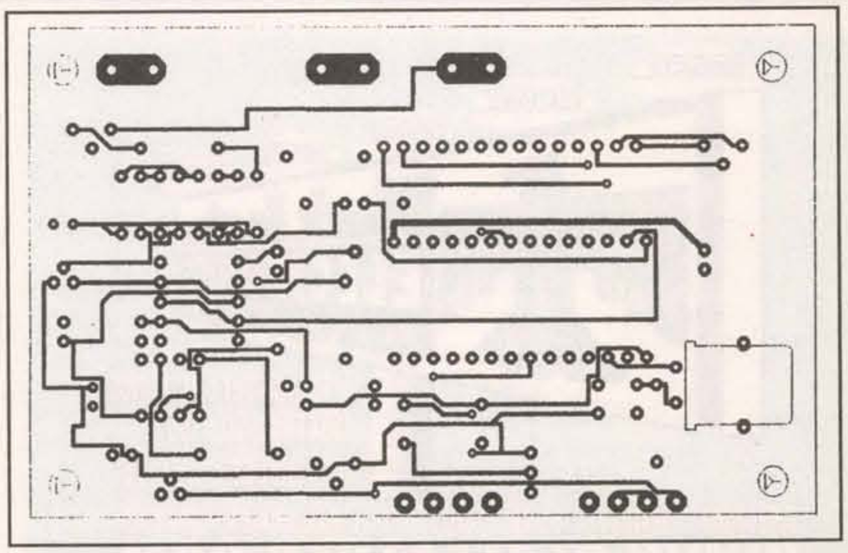
Prepare the case — refer to the drawing — first by drilling the 5/16 inch holes for the extension cord (this may vary according to the power cord used) and the .25 inch hole for the power switch and AC adapter socket as shown. Place the plastic lens in the display opening of the case, on



SILKSCREEN



TOP LAYER



BOTTOM LAYER

```
Code Instruction

01H  Clear display
38H  Set 8-bit data, 2-line display, 5x7 font
02H  Cursor to home position
06H  Increment cursor, do not shift display
0CH  Display on, cursor off, blink off
80H  Move to beginning of line 1
C0H  Move to beginning of line 2
****************************************************************
* PUT_CTRL - Write control word to LCD peripheral            *
*         Enter with control word in accumulator             *
*         Return with original value of X                    *
*         Delay ~4.5mS if A=$01 or $02 else delay ~120µS     *
****************************************************************
PUT_CTRL
        STX     TEMPX   ;Save X
        STA     PORTA   ;Write control word to LCD
        BCLR    7,PORTB ;RW->0 WRITE ENABLE
        BCLR    6,PORTB ;RS->0 SELECT COMMAND
        BSET    5,PORTB ;E->1
        BCLR    5,PORTB ;E->0
        LDX     #40     ;20*6~*1µS/~=120µS
L120U
        DECX            ;Delay loop ~120µS
        BNE     L120U   ;20-19,19-18...1-0
        CMP     #$02    ;Commands $01 & $02 req extra delay
        BHI     ARN5M   ;If command > $02 skip long delay
L5M
        JSR     ANRTS   ;JSR+RTS TAKES 12~ (just want delay)
        DECX            ;TAKES 3~ (X=0->1 on first pass)
        BNE     L5M     ;3~ Loop 256*18~*1µS/~=4.608mS Delay
ARN5M   LDX     TEMPX   ;Restore X

ANRTS   NOP
        NOP
        NOP
        NOP
        RTS             ;** RETURN **

****************************************************************
* PUT_LCD - Write data word to LCD peripheral               *
*         Enter with data word in accumulator               *
*         Return with original values of X & A              *
*         Delay ~120µS after data write                     *
****************************************************************
PUT_LCD
        STX     TEMPX   ;Save X
        STA     TEMPA   ;Save A
        STA     PORTA   ;Write data word to LCD
        BSET    6,PORTB ;RS->1
        BSET    5,PORTB ;E->1
        BCLR    5,PORTB ;E->0
        BCLR    6,PORTB ;RS->0
        LDX     #40     ;20*6~*1µS/~=120µS
L120    DECX            ;Delay loop ~120µS
        BNE     L120    ;20-19,19-18...1-0
        LDA     TEMPA   ;Restore A
        LDX     TEMPX   ;Restore X
        RTS             ;** RETURN **
```

Listing 2. Put_CTRL & Put_LCD

the inside. Using the four .125 inch spacers and four #4 screws provided, mount the PCB assembly into the top half of the case with the LCD pressed against the plastic lens, install the power switch, and the power receptacle into the case. Install the pre-programmed MC68HC705 into the socket. Be sure to observe pin 1. *Installing the chip backwards will result in its destruction.* Make sure the power switch is in the off position and plug in the wall transformer.

Put the switch in the on position and the display should read 000W-0000WH. Use POT3 to set the LCD contrast to your liking. NOTE: You may not have all 000s in the Watts display because it has not been calibrated yet. Don't worry, yet. Use POT2 to zero the Watts display. If it won't zero out, then worry.

At this point, it's time to connect Watts Showing to 120VAC. With the top half of the case laying face down — so the PCB is facing up — plug the power cord into a convenient outlet.

```
*****************************************************************
*  Beginning of main timing loop                                *
*       Loop is executed once every 10mS (exactly)              *
*       A pass through all major task routines takes            *
*       less than 10mS and then time is wasted until            *
*       the output compare flag gets set (every 100mS).         *
*       When an output compare triggers, the flag is            *
*       cleared & 50000 is added to the compare reg             *
*       so the next trigger will occur in exactly 100mS         *
*       (50000*2µS/cnt = 10mS).                                 *
*                                                               *
*       The variable TIC keeps track of 100mS periods           *
*       when TIC increments from 9 to 10 it is cleared          *
*       to 0 and seconds are incremented.                       *
*                                                               *
*                                                               *
*****************************************************************
MAIN1
        BRCLR  6,TSR,MAIN1 ;Loop here till OCF flag set
        LDA    OCMP+1 ;Low byte of OC register
        ADD    #$88    ;Low half of 50000
        STA    TEMPA   ;Save till high half calculated
        LDA    OCMP    ;High byte of OC register
        ADC    #$13    ;High half of 50000 (+carry)
        STA    OCMP    ;Update OC reg
        LDA    TEMPA   ;et low half of updated value
        STA    OCMP+1 ;Update low half of OC reg
* OC now = old OC + 50000, and OCF flag is clear
        LDA    TIC     ;Get current TIC value
        INCA           ;TIC=TIC+1
        STA    TIC     ;Update TIC
        CMP    #10T     ;10th TIC ?
        BLO    ARNC1   ;If not, skip next clear
        CLR    TIC     ;Clear TIC on 10th
ARNC1   EQU    *
* End of synchronization to 10mS TIC; Run main tasks and
* branch back to main within 100mS. Sync OK as long as
* no 2 consecutive passes take more than 200mS.
```

Listing 3. 10Ms Timing Routine

SAFETY NOTICE: There is 120VAC on the circuit board, so please use *extreme* caution. Use an AC voltmeter to measure the potential of the PCB ground to AC ground on an outlet. There should be no more than a few volts differential. If you read over 20VAC, then your circuit is not isolated and MUST be fixed before continuing. In some cases, a 'ghost' voltage reading of more than 20VAC could exist. To know if it's real, put a 100k resistor across PCB ground and AC ground and apply AC power. If it's a 'ghost' voltage, then it will drop to near zero VAC. If the voltage holds, it's real.

Disconnect AC power and connect a scope to the anode end of D1. Reconnect AC power and adjust POT2 up and down, using an insulated screwdriver, to a point where the pulses just stop. Now connect a 60W light bulb to the output cord. Turn on the light and the pulses should reappear on the anode of D1. Turn the light off and stand up the case so that the LCD is visible, and also with POT1 and POT2 accessible.

Turn the light on and adjust POT1 for a Watt reading of 60 ± 1 watts. Reset the zero point again by turning off the light and adjusting POT2 to the point at which the Watts display just goes to a 000 reading. Turn the light back on and readjust POT1 for 60 ± 1 watts. This time when the light is turned off, POT2 won't require much adjustment, if any, to reach the point of just zeroing the Watts display.

Try to keep any breeze away from the opto-isolator when calibrating. The stacked differential pairs are extremely sensitive to temperature gradients across the part. It will be impossible to properly calibrate if air currents are moving across U1.

Let the unit sit with power on for about 10 minutes and do one more series of adjustments for a final calibration. Keep in mind the thermal sensitivity of the opto-coupler and be sure it's shielded from air currents or direct incandescent light which might warm the part.

Turn off Watts Showing and unplug it from the 120VAC outlet. Put the strain relief's on the power cords and put both halves of the case together around each strain relief. Use the four screws to tighten the case halves and you're done.

Using Watts Showing

You can use Watts Showing to collect data on energy usage costs for appliances around your home or office or make sure that a power-strip's ratings won't be exceeded by all of the devices plugged into it. Take a freezer, for example. A typical household freezer will require 200-400 watts when the compressor is running. But the compressor only runs when its inside temperature exceeds the thermostatically-controlled value. At any given time, it may or may not be running. If you connect the freezer to 120VAC through Watts Showing, and let it run for a day, you can see the total watt hours accumulated over time. After allowing it to run for 24 hours, you can multiply the watt-hours accumulated by your local power provider's rate to get cost-per-day of freezer operation.

Electric rates average about $0.085 per kilowatt hour in the U.S. If your freezer used 2000 W/hr a day, the cost would be $.17 or $5.10 per month. Of course, the duty cycle will vary with the amount of insulation in the freezer and the ambient temperature where the freezer is located.

Finally, I would like to thank Steve Woodward for his design of the modified Gilbert Cell power measurement circuit. **NV**

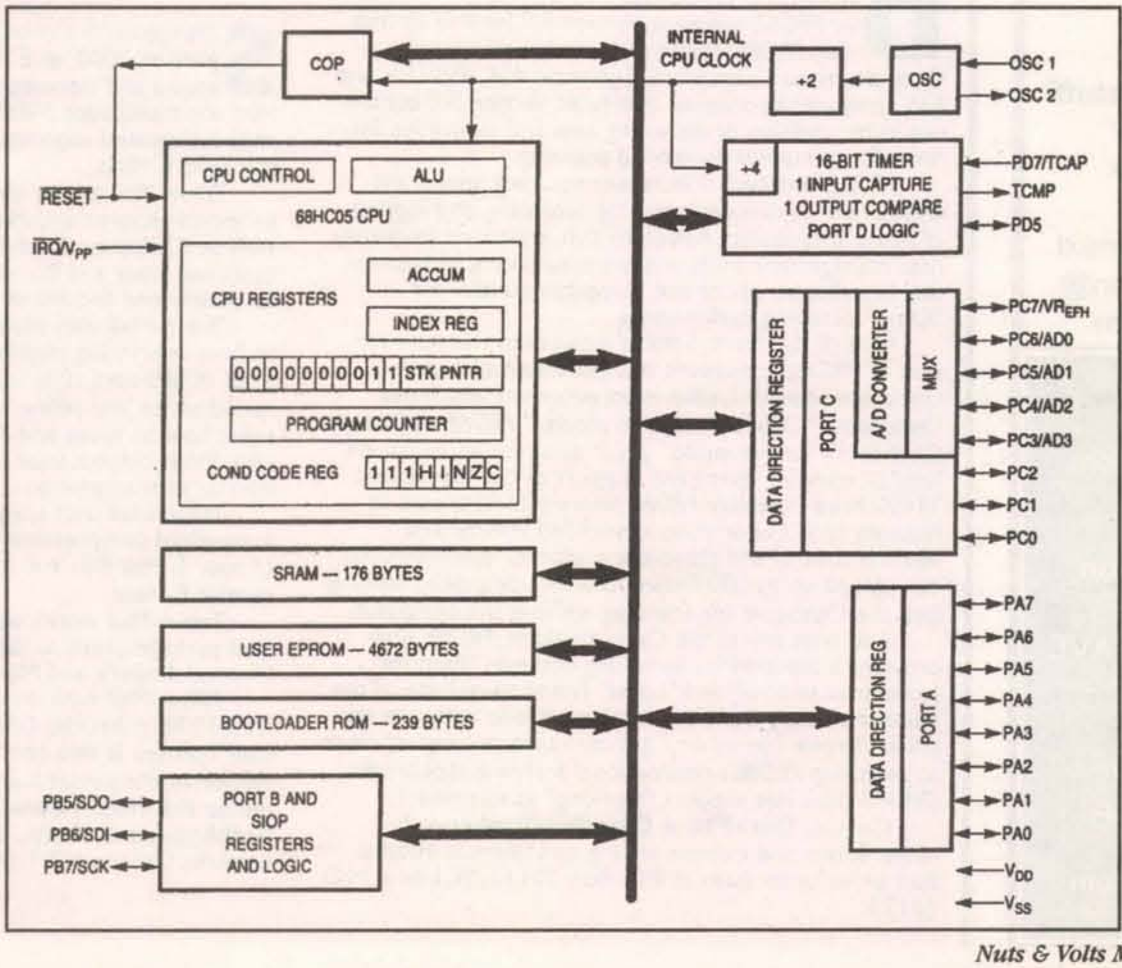


Figure 6 — MC68HC705P6 block diagram.

reader FeedBack

Dear Nuts & Volts:

I just received my first subscription issue of *Nuts & Volts*, June '99, and I just had to say how impressed I am with the wealth of information contained within.

As an electronics technician, it is very important to me to stay current with the changes in technology.

Your writers and contributors are very knowledgeable and seem eager to solve any reader problems with an enthusiasm that has driven me to want to expand my knowledge into other areas of electronics.

As I have not yet had the opportunity to send you a problem (my questions seem to get answered before I ask them), it is reassuring to know that there is such a knowledge base to seek advice from.

Case in point: I work for a Christian-run electronics repair facility in NY, and the owner built a cross 12' x 7' with flashing LEDs and in the center of the cross bar is the name JESUS in super bright LEDs. We have requests to build others, but needed to develop a self-contained power supply so the cross could be just plugged into a 110 VAC source.

On pages 22, 23 of June '99 was my answer for a low-voltage, high-current power supply.

Just for that reason, you have a reader for life. Keep up the great work.

Edward C. Anderson, Jr.
ecajr@acmenet.net

Dear Nuts & Volts:

A reader asked how to change the receive frequency of a Plectron monitor (Tech Forum question 5998). The advice given was correct, but a little incomplete.

While it is true that all you need to do is use a crystal of a different frequency, there is much more that you need to specify about the crystal besides its frequency.

For example, the crystal will almost certainly be an overtone unit, or one which oscillates readily at the third, fifth, or seventh harmonic.

Continued on page 86

Newsbytes

NEW RELEASE OF PROBE VERSION 5.0 SOFTWARE

DataFile, Inc. announces a new release of its popular *PROBE* software, Version 5.0, now in its fifth year. *PROBE* works exclusively with Optoelectronic's Optocom, Optoscan 456, 456 Lite, and 535 computer-to-scanner interfaces. Version 5.0 continues in its tradition of delivering new and innovative features for computer-controlled scanning.

PROBE Version 5.0 increases accuracy, speed, and control for unattended scanning, searching, and logging of active frequencies. Added to that, enhanced frequency data management tools and more functions to improve the overall ease of use and computer control for "Opto" scanning performance.

One of the more notable features in this new version of PROBE is support of Optoelectronic's new Optocom scanner. Unlike most programs which use Optocom's "OS535 Emulation mode," *PROBE* V5.0 uses Optocom's "native mode" which provides an enhanced level of scanning speed and support of the Optocom's 38400 baud capability. *PROBE* also supports access to features such as computer-controlled volume and squelch control and stand-alone scanner operation. You can upload up to 100 frequencies including delay settings into the Optocom for scanning without the computer.

And with any of the Opto products, *PROBE* now provides a function for switching between "Remote" (computer control) and "Local" (stand-alone) use of the scanner directly from the scanning screen with one simple keystroke. No other Optocom software comes close to matching *PROBE's* conventional scanning capabilities. (*PROBE* does not support "trunking" at this time.)

Contact **DataFile** at **Datafiles@aol.com** for more details and current pricing, and upgrade information or write to them at P.O. Box 20111, St. Louis, MO 63123.

USING TALK-N-MAIL TO BRING E-MAIL COMMUNICATION TO LIFE

SoftApproach Corporation has released Talk-n-Mail version 2000, an E-Mail software that brings multimedia and Internet technologies together for E-Mail communication. With Talk-n-Mail, you use a microphone, animated pictures, and other cool stuff to create and send E-Mails.

Talk-n-Mail is easy to learn and fun to use. It offers animated pictures and Mail Templates to cover areas such as Christmas, Birthday, Computer, Sports, Kids Only, and Love and Romance. Its documentation is easy to understand and full of attractive pictures.

Talk-n-Mail uses objects instead of an entire picture to hold everything together. An object can be an animal, a set of billboard-style text playing frame by frame, or a sound script. You define how an object looks like, and tell it how to move and how to respond to your mouse click. With objects, your imagination is the only limitation to your creativity.

Talk-n-Mail uses unique techniques plus the industrial standard compression technology to reduce the size of your E-Mail files and thus reduce the time to send or receive E-Mails.

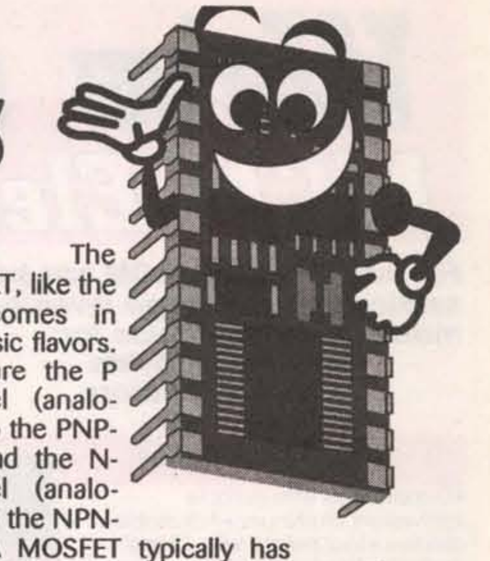
Talk-n-Mail works seamlessly with other popular E-Mail packages, such as Yahoo! Mail, America Online Mail, Hotmail, Eudora, and Microsoft Outlook.

Talk-n-Mail runs on Windows 95/98/NT and costs US $39.98. It has the Gift Pack discount for multiple user licenses. It also contains a fully functional Free Edition in the same package. For more information, please visit **http://www.Talk-n-Mail.com** or contact **SoftApproach Corp.**, 38 Brahms Ave., Toronto, Ontario, Canada, M2H 1H4.

Continued on page 86

STAMP APPLICATIONS

by Lon Glazner



Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

Stamp-Controlled High Power H-Bridge

It seems like quite a few people are using BASIC Stamps as the brains in low-level robotics. Because of simplicity, ease of use, and versatility, it's no wonder that the BASIC Stamp is finding wide spread use with hobbyists and amateur robotics groups.

Overview

On the Stamp List – an informative E-Mail list provided by Parallax – I routinely see questions about how to bridge the gap between power devices and the BASIC Stamp. Often times, the applications require relatively high power motors for robotics, or other more industrial needs. I thought it might be interesting to share my experiences with an IC that I've used several times in the past.

This circuit can be used for controlling high current motors, driving relays, controlling lamps, and powering heating elements, just to name a few of the possible applications.

Defining the Design

The first thing that needs to be defined is what I mean by "high power." For the purposes of this article, I think we should limit it to about 30V and no more than 30A (so anything in the area of 900W). In the real world of hydroelectric dams and power utility companies, 900W is minuscule. But here, in the land of BASIC Stamps, I feel pretty comfortable using the "high power" moniker for this circuit.

One of the first concerns a designer has to face when confronted with high power requirements is the question of power dissipation. Any voltage drop across a device carrying current is accompanied with power being dissipated in the device as heat. In high current applications, any voltage drop can create significant needs for heatsinks and other means of removing the heat from the current carrying device.

For instance, take a power diode with a forward voltage drop of 0.5V. This diode carrying a load current of 1A would be required to dissipate 0.5W of power (Power = Voltage*Current; P=VI). That is not too big of a deal. But increase the diodes load current to 30A and you've got a problem, a 15W problem.

For this reason, designers will often attempt to reduce the voltage drops that might be found in a high current application. A device that is ideal for this is the MOSFET (are you ready for this – metal-oxide-semiconductor-field-effect-transistor), which can be considered a voltage-controlled switch. Like the BJT (bipolar-junction-transistor, such as a 2N3904), the MOSFET can be biased into its active region (not all the way on, or all the way off). But in power switching applications, that is rarely done. In this design, the MOSFETs will be used either in the on or off state. Many applications require a load to be "turned on/off." This often means closing (on) or opening (off) a current path to your load, and MOSFETs are ideal for this purpose.

Previously, I defined high power as meaning about 900W. In a perfect system, we would lose no power in our MOSFETs as they switch our load into or out of the circuit. Therefore, all of the 900W would be dissipated by our load. But, of course, this isn't the case.

A little bit of information about MOSFETs would probably be helpful at this point. As I mentioned earlier, a MOSFET can be considered a voltage-controlled switch. This differs from a BJT which is a current-controlled switch. The MOSFET, like the BJT, comes in two basic flavors. They are the P channel (analogous to the PNP-BJT) and the N-channel (analogous to the NPN-BJT). A MOSFET typically has three points of connection. They are: the gate, drain, and source (similar to the base, collector, and emitter of a BJT).

All MOSFETs have an "on resistance." This can be considered a resistor in series with your load. In a particular MOSFET data sheet, this

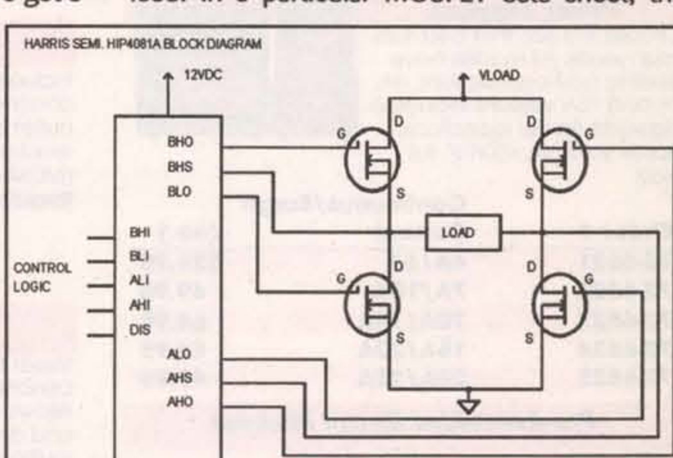


Figure 1: Block Diagram of H-bridge and HIP4081A

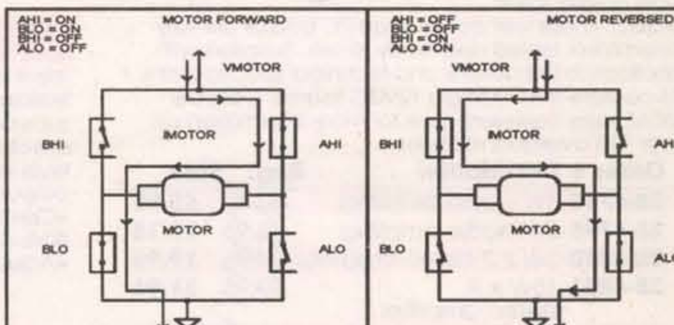


Figure 2: Current Flow Through an H-bridge

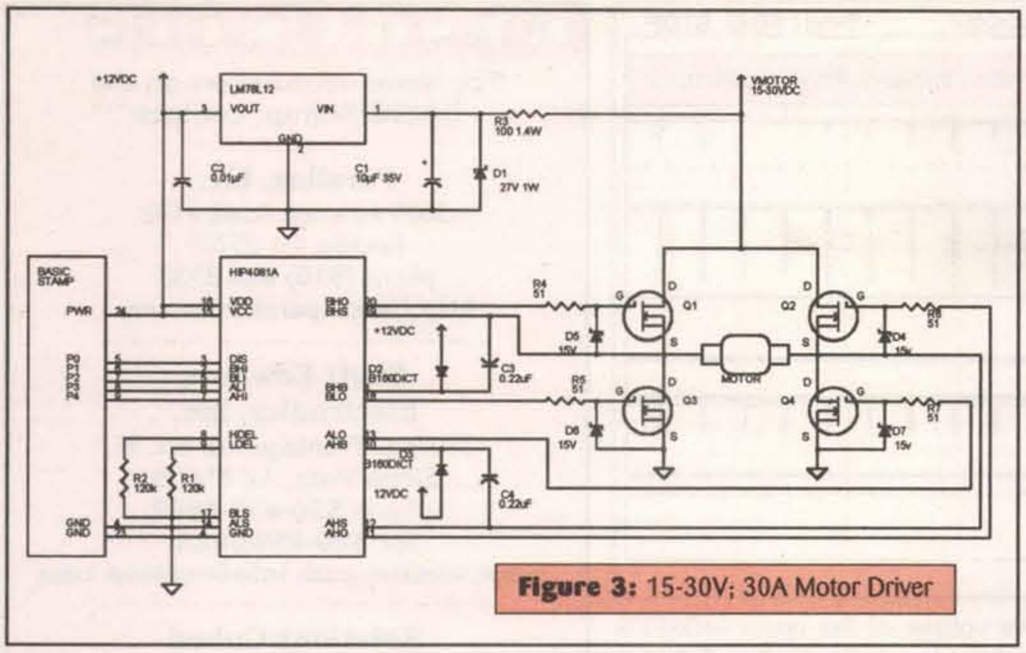


Figure 3: 15-30V; 30A Motor Driver

value is typically listed as Rdson (resistance from drain to source while the device is on). N channel MOSFETs typically have a lower Rdson resistance as compared to the P channel types. Most power dissipated by a MOSFET is due to the Rdson value. The Rdson value is also dependent on the "gate drive voltage" (voltage on the gate when referenced to the source).

Therefore, for high power applications, you would want to do several things to minimize power dissipation in your circuit. You would use N-channel MOSFETs with low Rdson values. It is desirable to maximize the gate drive voltage in order to minimize the Rdson of your MOSFET. You would also ensure that when you turn your MOSFET on, the gate drive voltage would have a fast rise time to minimize the amount of time that the MOSFET is in its active region (the fall time of the gate drive voltage is also important when turning a MOSFET off).

This brings us to the concept of an H-bridge. The H-bridge is a configuration of four switching devices that allows you to change the direction of current flow through a load. This is done by selecting which pair of switches are on and which pair are off. This is particularly useful for controlling bi-directional motors.

We'll assume that our load is a motor for this design, although many types of loads could be controlled with the circuit that will be defined here. An H-bridge requires that there be two switches located between the system voltage supply and the load, and two switches located between the load and the system ground return. To reduce power dissipation, it is desirable to use N channel MOSFETs for each of the four switches. This creates a significant problem. To fully turn on an N channel MOSFET, the gate drive voltage should be about 12V above the voltage at that MOSFET's source. In an H-bridge, the high side switches will have their source pins at the system voltage level when they are on. For example, in the system being designed here, I'll be using 18-20VDC for the system voltage. That means I'll need roughly 30-32V to drive my high side N channel MOSFETs. Things are definitely getting complicated!

Connecting the Parts

Have you ever looked at an engineering problem before and said "Hey, this should definitely be easier than it is turning out to be?" Well, I think the people at Harris Semiconductor (www.semi.harris.com) did just that when they designed the HIP4081A H-bridge

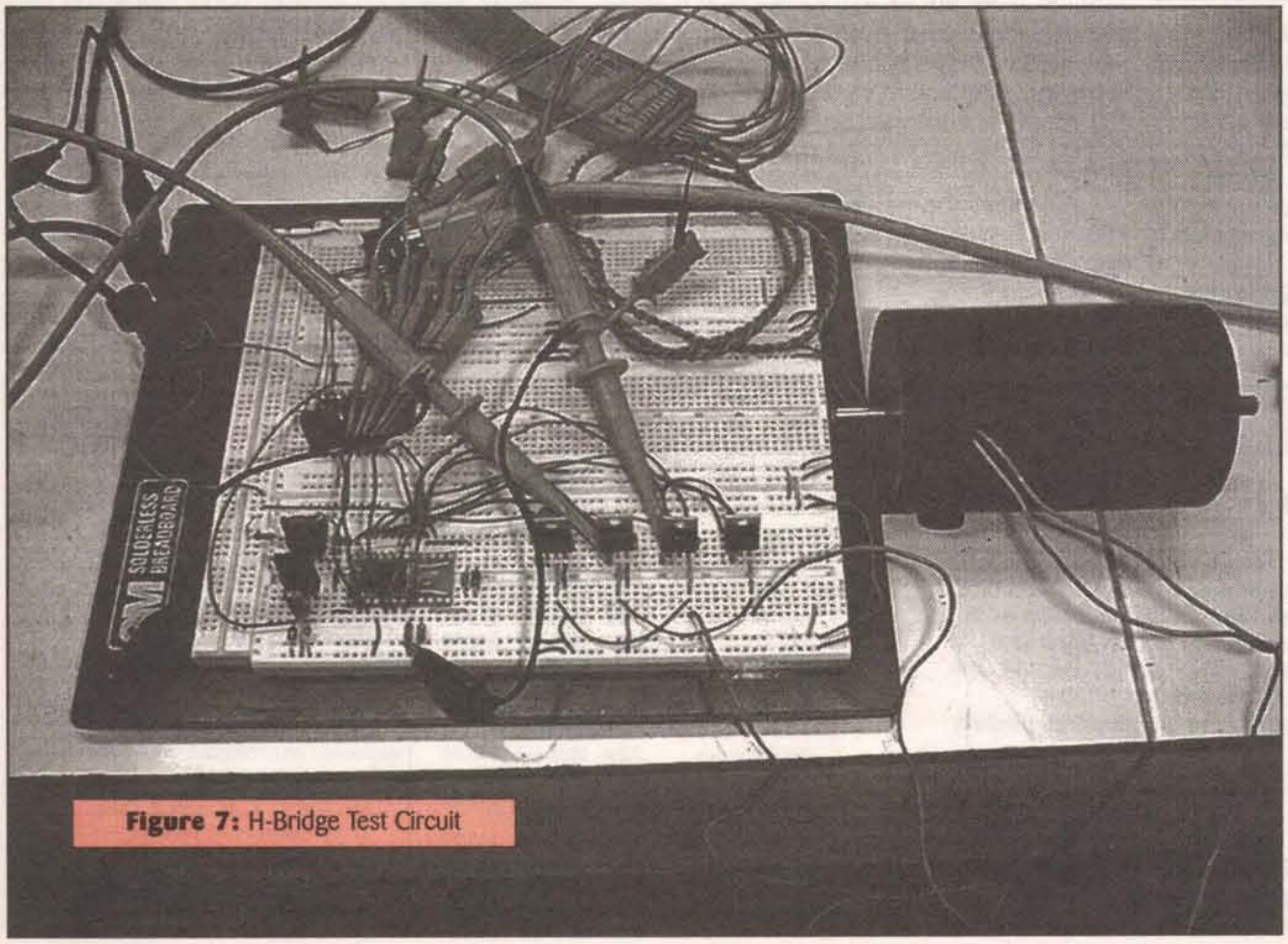


Figure 7: H-Bridge Test Circuit

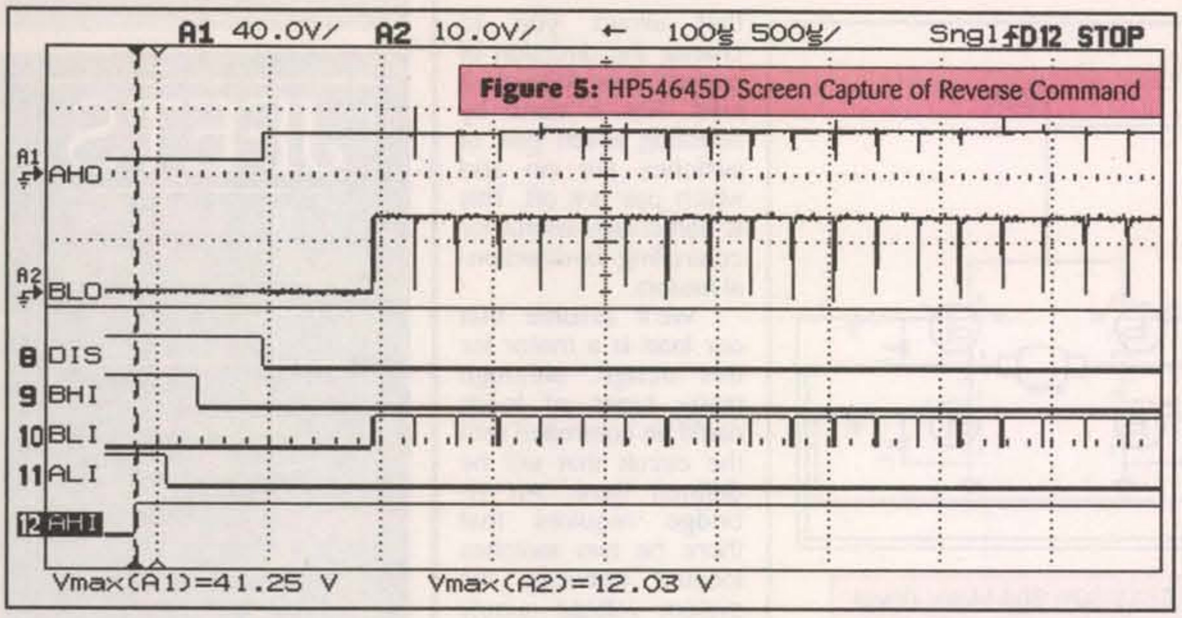


Figure 5: HP54645D Screen Capture of Reverse Command

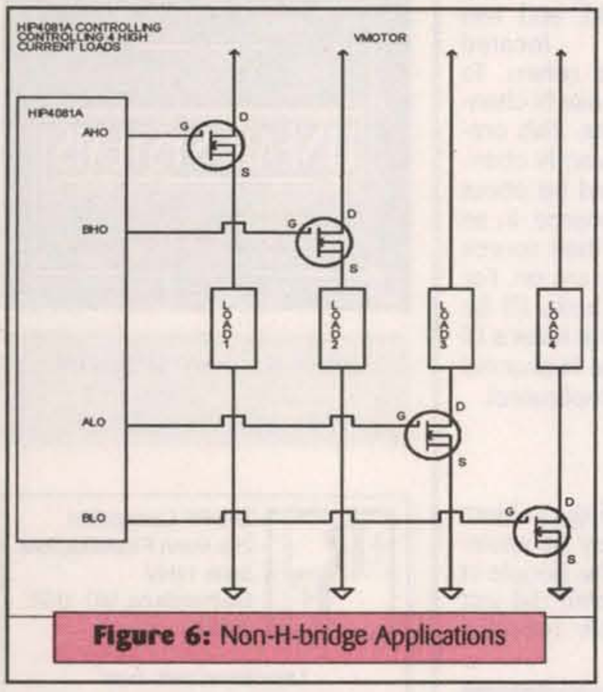


Figure 6: Non-H-bridge Applications

driver chip.

This device provides a logic level interface to an all N-channel MOSFET H-bridge. It also prevents things like shoot-through (inadvertently turning on the wrong switches and shorting your supply to ground through your H-bridge, usually resulting in transistors with cracks, missing legs, and that funny melted electronics smell).

The HIP4081A has on-board charge-pumps and upper bias supplies that are used to raise the gate drive voltage of the upper MOSFETs above the system bus voltage when they are turned on. This is routinely called a "high-side driver;" two of which are required for an N-channel H-bridge. Figure 2 shows the logic states required for changing the current flow in an H-bridge. In many loads, the amount of current passing through the load is required for control, as well as the current direction. With a motor as your load, this translates to controlling both motor speed and direction. To control speed you can turn on the appropriate high side switch, and then pulse width modulate (PWM) the low side switch.

For the HIP4081A, the control pins are considered high for assertion, meaning that a logic high enables that function. For instance, a logic high (+5V) at the ALI and BHI pins would turn on the B high side driver, as well as the A low side driver.

Component selection for the HIP4081A is relatively simple. I selected the Harris HRF3205 MOSFET which has an Rdson of about eight milli-ohms (0.008 ohms) for the four H-bridge switches. The charge-pump diodes selected were from Digi-Key, but virtually any 60V Schottky diode would work for this application. The charge-pump capacitor (C3,C4) should be at least 10 times the input capacitance of your MOSFET.

The HRF3205 has an input capacitance of 4000pF. I used 0.22uF capacitors, which are oversized but worked fine. The HRF3205 is rated for 55V and 75A. At 30V and 30A, I think we're well within its safe operating range.

RESOURCES

For more information on the BASIC Stamp, contact:

Parallax, Inc.
3805 Atherton Road, #102
Rocklin, CA 95765
phone **(916) 624-8333**
http://www.parallaxinc.com

Scott Edwards Electronics, Inc.
1939 S. Frontage Rd. Ste. F
Sierra Vista, AZ 85635
phone **520-459-4802**
fax **520-459-0623**
www.seetron.com info@seetron.com

Solutions Cubed
Lon Glazner
3029 Esplanade Suite F
Chico, CA 95973
E-Mail: **lon@solutions-cubed.com**
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Phone: **530-891-8045**
Fax: **530-891-1643**

I included a power supply circuit that is required for powering the HIP4081A with the motor voltage. This was also used to provide power to the BASIC Stamp. Some additional protection should be added to any noisy circuit to help protect the logic components. In this case, a bi-direction transient voltage suppressor (TVS) could be placed across the motor. Furthermore, RC snubbers, additional supressors, zener diodes, and poly-fuses could be used to reduce or contain transient voltage spikes.

There are protective gate resistors and zener diodes on each MOSFET which will slow the rise and fall times of the gate drive voltage but they do not have much effect on the performance of this particular circuit. Figure 3 shows the finished schematic.

Power dissipation for this circuit at 30A is around 15W. Additionally, this power dissipation is split between two semiconductors (7.2W = 30A2*0.008ohms; P=I2R). This makes heatsinking easier. At 10A, virtually no heatsinking would be required.

MOSFETs are also ideal for paralleling. They

'NV_SEP99.BS2 - This BASIC Stamp 2 program runs a high current motor one direction, stops the motor, and runs it in 'the other direction. This is repeated until power is removed.

```
DISpin  CON     0                           'Disable input, logic high disables all outputs
        BHIpin  CON     1                   'B high side control pin, a logic high turns on B high side driver
        BLIpin  CON     2                   'B low side control pin, a logic high turns on B low side driver
        ALIpin  CON     3                   'A low side control pin, a logic high turns on A low side driver
        AHIpin  CON     4                   'A high side control pin, a logic high turns on A high side driver

        PWMreg  VAR     BYTE                'Pulse width modulation duty cycle register
        DURreg  VAR     BYTE                'Pulse width modulation duration register
        Loop    VAR     BYTE                'FOR...NEXT loop variable

        HIGH    DISpin                      'Disable H-bridge on power up
        PAUSE   500

        DURreg  =100                        'Duration = 100
        PWMreg  =250                        'Duty cycle is 98%

FORWARD
        HIGH    DISpin                      'Disable all driver outputs(stops motor)
        PAUSE   1000                        'Wait 1s then set input values
        HIGH    BHIpin                      'Enable B high side driver
        LOW     BLIpin                      'Disable B low side driver
        LOW     AHIpin                      'Disable A high side driver
        LOW     ALIpin                      'Disable A low side driver(will PWM it below)
        LOW     DISpin                      'Enable all driver outputs(only B high side in this case)

        FOR     Loop = 1 to 25
        PWM     ALIpin,PWMreg,DURreg        'PWM A low side driver
        NEXT

REVERSE
        HIGH    DISpin                      'Disable all driver outputs(stops motor)
        PAUSE   1000                        'Pause 1s then set input values
        HIGH    AHIpin                      'Enable A high side driver
        LOW     ALIpin                      'Disable A low side driver
        LOW     BHIpin                      'Disable B high side driver
        LOW     BLIpin                      'Disable B low side driver(will PWM it below)
        LOW     DISpin                      'Enable all driver outputs(only A high side in this case)

        FOR     Loop = 1 to 25
        PWM     BLIpin,PWMreg,DURreg        'PWM B low side driver
        NEXT
        GOTO    FORWARD                     'Change direction again

END
```

work well in current sharing applications. The current that the device passes is based, to a degree, on the Rdson value of the MOSFET (and, of course, on the load resistance and bus voltage). In addition to being dependent on the "gate drive voltage," the Rdson value will increase as the MOSFET's junction temperature increases. So, if a MOSFET gets hot, it will pass less current because of a increasing Rdson value. Therefore, if two (or more) MOSFETs are connected in parallel, and one begins to heat up, it will eventually begin drawing less current than the cooler MOSFET of the pair, and subsequently cool down. This is assuming that all of the MOSFETs paralleled are of the same type; 100A plus H-bridge circuits can be realized with parallel MOSFETs and an H-bridge driver like the HIP4081A.

Writing the Code

The BASIC Stamp has limited PWM capability. The PWM command works just fine, but you can't have it run in the background (perform serial communication, etc., while doing PWM). Many applications will require a separate PWM generating device external to the BASIC Stamp. This application simply controls the HIP4081A by running the motor in one direction, stopping the motor, and then running it in the other direction. This should give most people insight into the simplicity of H-bridge control with a logic level device.

In the code example in Figure 4, the DISpin (disable pin) was used to shut down the H-bridge driver. You can see in Figure 4 that the gate drive voltage on the A high side switch stayed at about 30V. The system was running with an 18VDC bus. Since the HIP4081A was powered by a 12VDC regulator, you would expect the gate drive voltage to be 12VDC + 18VDC = 30VDC, which it was. There is quite a bit of noise in this system as it stands. This can be seen as voltage spikes and noise coupling from scope probe to scope probe. Most of this noise would go away if the design were on a PCB and not on a solderless breadboard. The PWM signal can be seen on both the logic level BLI pin, and the low side driver output, BLO.

You can also see that, although the AHO output is enabled in the BASIC Stamp code via the AHIpin, the A high side driver is not enabled until the DISpin is taken low (0V), thus enabling individual control of the various output drivers.

Harris Semiconductor makes a part similar to the HIP4081A, the HIP4080A. The HIP4080A is designed specifically for H-bridge control. For that reason, it would require fewer I/O lines to interface to. But I felt that the HIP4081A provided for a multitude of high current applications other than H-bridge control. So, I felt it might have wider appeal to the readers of this column. The parts are so similar, though, that virtually all information on the HIP4081A that was provided in this article holds true for the HIP4080A. Figure 4 gives an idea of how some non-H-bridge applications might appear.

In Closing

It's pretty difficult to come up with circuits that will have mass appeal, and fit them into a monthly article format. But I think this is a good one. There are quite a few parts out there in the electronics market that take a lot of anguish out of what would otherwise be a bear of a design. The Harris Semiconductor parts that I detailed here are great examples of the work many semiconductor manufacturers are doing these days.

Stop by and take a look at their web site. And, while you're at it, swing by the Maxim, Linear Technologies, Allegro, and Unitrode web sites. And, if you see anything that catches your eye, drop me an E-Mail. If it seems to work well with a BASIC Stamp, I might just write an article on it (and, of course, give you credit for pointing it out to me). **NV**

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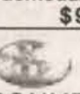

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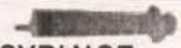

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AUGUST 1999

AUGUST 1

IN - ANGOLA - Hamfest. Land of Lakes ARC, Bill Brown WD9DSN, 219-475-5897. E-Mail: sharon.l.brown@gte.net

OH - RANDOLPH - Hamfest. Portage County Fairgrounds. 8am-4pm. VE Exams. Talk-in: 145.39 600 MHz. Portage ARC, Joanne Solak KJ3O, 330-274-8240. E-Mail: ljsolak@apk.net Web: http://parc.portage.oh.us

VA - BERRYVILLE - Winchester Hamfest. Clarke County Ruritan Fairgrounds. 6am. VE Exams. Talk-in: 146.82 (-) W4RKC repeater. Shenandoah Valley ARC, Guy Avey W3INT, 540-678-9970; Jane Barb KD4IET, 540-955-1745. E-Mail: ibarb@visuallink.com Web: http://www.Vvalley.com/svarc/hamfest or http://www.visuallink.net/shenvalleyarc

AUGUST 6-7

TX - AUSTIN - Texas State ARRL Convention. Austin ARC, Austin Repeater Org & Texas VHF-FM Society, Joe Makeever W5HS, 512-345-0800. E-Mail: jomak@ibm.net Web: http://www.repeater.org/summerfest/

AUGUST 6-7-8

SD - WATERTOWN - Dakota Division Convention. Lake Area Radio Klub, Jerry Hegg N0JH, 605-886-7151. E-Mail: n0jh@dailypost.com

AUGUST 7

CA - CHICO - Hamfest. Golden Empire ARS, Muriel Pope K6GSK, 530-342-4765. E-Mail: k6gsk@w6rhc.org

CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

IL - CARLINVILLE - Hamfest. Macoupin County Fairgrounds, Rt. 4, I-55 exit 60. 7am-12pm. Talk-in: 146.82- or 443.400+ 103.5PL. Macoupin County ARC, Tim Jones 217-627-2355. KA9VIV E-Mail: jester25@ctnet.net. Jim Pitchford N9LQF, E-Mail: esda@ctnet.net

IL - QUINCY - Hamfest. Western Illinois ARC, Jim Funk N9JF, 217-336-4191. E-Mail: jfunk@adams.net Web: http://www.qsl.net/s9awe

ME - ST. ALBANS - Hamfest. Snow Mobile Club. Howard WA1SBI, 207-876-3702

MI - TAWAS - Hamfest. Iosco County AR Enthusiasts, John Hanley KA8AIP, 517-756-2845. E-Mail: ka8aip@centuryinter.net Web: http://www.oscoda.net/icare/

MO - CRANE - Hamfest. City Park. 8am-3pm. Talk-in: 145.330-. VE testing. Lonnie Allen, 417-723-5671. E-Mail: n0tbo@gte.net

MO - SPRINGFIELD - Hamfest. Southwest Missouri ARC, Karen Thorpe N0TDW, 417-889-6775. E-Mail: n0tdw@juno.com

NY - PLATTSBURGH - Hamfest. Champlain Valley ARC, Bernard Jakobetz KC2ALG, 518-643-9657

NY - WEEDSPORT - Hamfest. Auburn ARA, Joe Kahler WA2NGX, 315-364-5135. E-Mail: htx@usa.net

OH - COLUMBUS - Hamfest. Aladdin Shrine Facility. 8am-3:30pm. VE Exams. Talk-in: 147.24 receive/147.84 transmit. Voice of Aladdin ARC, Jim Morton KB8KPJ, 614-846-7790

PA - LEWISTOWN - Hamfest. Decatur Township Fire Co. Grounds, US 522. Talk-in: 146.91. JVARC, Richard Yingling 717-242-1882

PA - MATAMORAS - Hamfest. Tri-State ARA, Dave W2DRH, 914-856-2529; Ray WY2D, 914-856-1733; Rich K3BBC, 570-559-7401

AUGUST 7-8

WA - SPOKANE - ARRL Eastern WA Section Convention. University High School, 10212 E. 9th Ave. Sat: 9am-5pm, Sun: 8am-12pm. VE Exams. Neil Gallup N7LVO, 509-928-7442. E-Mail: n7lvo@cet.com Betsy Ashleman N7WRQ, 509-448-5821. E-Mail: n7wrq@aol.com Web: http://www.iea.com/~n7utg

AUGUST 8

IA - AMANA - Hamfest. Cedar Valley ARC, Wayne Kolosik KI0FE, 319-393-4224. E-Mail: ki0fe@usa.net

IL - PEOTONE - Hamfesters Hamfest. Will County Fairgrounds. Tom Davis KB9NUQ, 708-210-9548; David Brasel NF9N, 708-448-0580. E-Mail: nf9n@aol.com or tdavis@internetplus.net

OH - LISBON - Hamfest. Triangle ARC, Mike Mays KB8JNM, 330-386-6021. E-Mail: mike.mays@usa.net Web: http://www.qsl.net/tarc

OH - MARTINS FERRY - Hamfest. Triple States RAC, Ralph McDonough K8AN, 740-546-3930. E-Mail: k8an@aol.com Web: http://www.qsl.net/tsrac

AUGUST 14

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

ME -ST ALBANS - Hamfest. Piscataquis ARC, George Dean WA1JMM, 207-965-8864. E-Mail: wa1jmm@midmaine.com Web: http://www.qsl.net/parc/

NY - WESTMORELAND - Hamfest. Rome RC, Jack Roux KB2TXR, 315-336-1391

OH - NELSONVILLE - Hamfest. Sunday Creek AR Federation, Russell Ellis N8MWK, 740-767-2226. E-Mail: scarf@hocking.edu

VT - CHARLOTTE - Hamfest. Burlington ARC, Ralph Stetson KD1R, 802-878-6454. Web: http://homepages.together.net/~kd1r/fest99.htm

WV - HUNTINGTON - Hamfest. Tri-State ARA, Dwight Smith WB8JPJ, 304-522-7865 eves; 304-523-6675 days. E-Mail: wb8jpj@arrl.net E-Mail: tara.amateur.radio@juno.com

AUGUST 15

CA - GOLETA - Hamfest. Santa Barbara ARC, Chuck Stersic N6CJL, 805-563-6062. E-Mail: chuckstr@west.net

CO - GOLDEN - ARRL Colorado State Convention. Jefferson County Fairgrounds, 15200 W. 6th Ave. (Indiana Exit). 8:30am-2pm. Denver Radio Club, Bob Lindell N0YIX, 303-422-0610. E-Mail: KB0QAB@arrl.net Web: http://users.ntr.net/~chastain/hamradio

IN - LAFAYETTE - Hamfest. Tippecanoe County Fairgrounds. Talk-in: W9REG 147.135/443.775. E-Mail: ddull@compuserve.com

KY - LEXINGTON - Hamfest. National Guard Armory. 8am-4pm. VE Exams. Talk-in: 146.760-. John Barnes KS4GL, 606-253-1178. E-Mail: KS4GL@juno.com Web: http://www.qsl.net/k4kjq/

MA -ADAMS - Hamfest. Northern Berkshire ARC, Joel Miller N1WCF, 413-442-2609. E-Mail: n1wcf@nobarc.org

MA - CAMBRIDGE - Flea at MIT. Albany and Main Sts. 9am-2pm. Talk-in: 146.52 & 449.725/444.725 W1XM/R PL 114.8 (2A). Nick Altenbernd KA1MQX, 617-253-3776 (9-5). Web: http://web.mit.edu/w1mx/www/swapfest.html

MI - JACKSON - Hamfest. Jackson Community College. VE Exams. Talk-in: 146.88 W8JXN. Cascades ARS, Dennis Byrne KC8IJZ, 517-522-4058. E-Mail: byrneda@voyager.net Web: http://www.qsl.net/cars-jxn/

NJ - BAYVILLE - Hamfest. Jersey Shore ARS, Bob Murdock WX2NJ, 732-269-6379. E-Mail: JARSFEST@aol.com Web: http://members.aol.com/jarsfest/jarsfest.html

NY - DEPEW - Hamfest. Hearthstone Manor, 333 Dick Rd. Lancaster ARC, Luke Calianno N2GDU, 716-634-4667. E-Mail: lcalianno@freewwweb.com Web: http://hamgatel.sunyerie.edu/~larc/GreaterBuffaloHamfest.ht

OH - WARREN - Hamfest. Trumbull County JVS School, Educational Hwy. Warren ARA, Frank Fitzhugh KD8KJ, 330-652-0452, E-Mail: kd8kj@onecom.com Ray Solinger N8HRZ, 330-652-5028, E-Mail: n8hrz@onecom.com

PA - YORK - Swapfest and Auction. York VO Tech School, Pauline Dr. (1 blk S of I-83 Exit 6, Rt 74S). Talk-in: 146.865. Swap Fest, John Salony (Ph) 717-741-1780; Greg Towson (fax) 717-741-0874. Gene Warner E-Mail: ad3e@arrl.net

WA - NORTH SEATTLE - Antique Radio Swap Meet. Shoreline Museum Parking Lot, N. 175th & Linden Ave. 9am-1pm. Puget Sound Antique Radio Assn., 425-747-1323 or 206-546-5495. Web: http://www.eskimo.com/~hhagen/psara.html

AUGUST 21

CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

CANADA - MANITOBA - AUSTIN - MARM Hamfest. Dave Snydal VE4XN, 204-728-2463. E-Mail: dsnydal@mb.sympatico.ca Web: http://WWW.MBNET.MB.CA/~donahue/a ustin.html

GA - ELLIJAY - Hamfest. Legion Rd., Telephone Co. Pavilion off old Hwy 5. 8am-12:30pm. Talk-in: 146.985. Ellijay ARS, Dot Beam K4PPS, 706-276-6660

IN - WARSAW - Hamfest. Kosciusko County Fairgrounds. 8am-2pm. VE Exams. Hoosier Lakes Radio Club, Loren Melton WB9OST, 219-858-9374 eves. E-Mail: WB9OST@WAVEONE.NET

NJ - OAKLAND - Flea Market. American Legion Hall, 65 Oak St. 8am-Noon. Talk-in: 147.49 in/146.49 out & 441.175 in/446.175 out & 146.52 simplex. Ramapo Mountain ARC, Tony Cassera N2KDZ, 973-839-3564. E-Mail: acassera@intac.com

NY - ITHACA - Hamfest. Tompkins County Airport. Talk-in: 146.97 (-600). Tompkins County ARC, David Flinn W2CFP, 607-533-4797. E-Mail: dave@starflinn.com Web: http://www.compcenter.com/~tcarc

TX - GREENVILLE - Hamfest. Sabine Valley ARA, Michael Ihry N5KB, 903-883-3789. E-Mail: mihry@argontech.net Web: http://www.thehallco.com/SVARA

VA - VINTON - Hamfest. William Byrd High School, Washington Ave. 9am-3pm. VE Exams. Roanoke Valley ARC, Mike Marsh KF4MUB, 540-389-3056. E-Mail: mikekf4mub@aol.com Web: http://ourworld.compuserve.com/homepages/fcupp/rvarc.htm

WA - LONGVIEW - Hamfest. Cowlitz County Expo Center, Fairgrounds. 9am-1pm. Talk-in: 147.26+ K7ZVV repeater. Lower Columbia ARA, Bob Morehouse KB7ADO, 360-425-6076 (after 6pm wkdys). E-Mail: kb7ado@aolcom Web: http://www.qsl.net/nc7p/

AUGUST 21-22

AL - HUNTSVILLE - Convention. Von Braun Center. Sat: 9am-4:30pm, Sun: 9am-2:30pm. Southeastern Division, Scotty Neustadter W4WW, 256-880-8004. E-Mail: scotty@hiwaay.net.

NM - ALBUQUERQUE - Duke City Hamfest. Marcus Lieberman KM5EH, 505-836-1724. Fax: 505-352-6154. E-Mail: buckml@lobo.net Web: http://www.qsl.net/dchf

AUGUST 22

KS - SALINA - Hamfest. Central Kansas ARC. Ron Tremblay WA0PSF, 785-827-8149. E-Mail: tremblay@midusa.net

MI - CORUNNA - Hamfest. Genessee County RC, Mid MI Wireless Assn., Lapeer ARC, Shiawassee ARA & Bay Area ARC. Rosemary Podsiadlik N8UHY, 517-288-4145

MO - ST. CHARLES - Hamfest. Blanchette Park. 6:30am-1pm. Talk-in: 146.67. St. Charles ARC, Ken Fieser KB0VLN, 314-428-4383. E-Mail: kfieser@aol.com Web: http://www.qth.com/wb0hsi/

NE - OMAHA - Hamfest. AK-SAR-BEN ARC, Gerry Gross WA6POZ, 402-895-7367. E-Mail: wa6poz@aol.com Web: http://www.qsl.net/k0usa

NJ - MULLICA HILL - Hamfest. Gloucester County ARC, John Schumacher N2AWD, 215-238-4955. E-Mail: schumacher@kyw.com Web: http://users.snip.net/~gradywhite

NY - YONKERS - Hamfest. Yonkers ARC, John Costa WB2AUL, 914-969-6548. E-Mail: wb2aul@aol.com

AUGUST 27-28

LA - NEW ORLEANS - New Orleans International DX Convention, Don Boudreau W5FKX, 504-737-9733. E-Mail: dboudr@lsumc.edu Web: http://www.gnofn.org/~w5ru/

AUGUST 27-28-29

CT - ENFIELD - Convention. Harley Hotel, 1 Bright Meadow Blvd. (off Rt. 5). Eastern VHF/UHF Society, Bruce Wood N2LIV, 516-265-1015. E-Mail: wzlv@ntplx.net E-Mail: bdwood@erols.com Web: http://uhavax.hartford.edu/~newsvhf

AUGUST 28

FL - TAMPA - Hamfest. Tampa ARC & Tampa Bay ARS, Biff Craine K4LAW, 813-222-5022 or 813-265-4812. E-Mail: scraine1@tampabay.rr.com

COMPUTER SHOWS

AGI Shows, 317-299-8827.
E-Mail: info@agishows.com
http://www.agishows.com

Blue Star Productions
612-788-1901
http://www.supercomputersale.com

Computers And You, 734-283-1754.
www.a1-supercomputersales.com

Computer Central Shows
847-412-1900 & 1-888-296-6066.
E-Mail: compcent@megsinet.net
www.computercentralshows.com

Five Star Productions
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www.fivestarshows.com

Georgia Mountain Productions
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georgiamountain.com

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Gibraltar Trade Center, Inc.
810-465-6440. Mt. Clemens, MI.

KGP Productions
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E-Mail: kgp@mail.com

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http://www.marketpro.com

MarketPro, Inc., 301-984-0880.
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Narisaam Computer Show
770-663-0983.
E-Mail: narisaam@aol.com
Web: http://www.shownsale.com

Northern Computer Shows
978-744-8440
E-Mail: inquiries@ncshows.com
Web: ncshows.com

Peter Trapp Computer Shows, 603-272-5008. Web: www.petertrapp.com

Events CALENDAR

IN - LA PORTE - Hamfest. County Fairgrounds. 7am-1pm. Talk-in: 146.610 (131.8PL), 146.520 simplex. La Porte ARC, Neil Straub WZ9N, 219-234-7525. E-Mail: nstraub@netnitco.net Web: www.geocities.com/siliconvalley/byte/1653
KS - CHANUTE - Hamfest. Central Park Pavilion. 9am-1pm. Talk-in: 146.745. Chanute Area ARC, Charlie Ward WD0AKU, 316-431-6402
MA - GARDNER - Hamfest. Mohawk ARC, John Dould AE1B, 978-249-5905. E-Mail: ae1b@gis.net
TX - GAINESVILLE - Hamfest. Civic Center. 7am-5pm. Bob Ray, 940-665-2544. E-Mail: bray@mortexinfo.net
WV - WESTON - Convention. Jackson's Mill Conference Center. 8am-11pm. West Virginia State AR Council, Dick Fowler N8FMD, 304-623-9479. E-Mail: n8fmd@neumedia.net Web: http://qsl.net/wvsarc

AUGUST 28-29

CO - WOODLAND PARK - Hamfest. Mountain ARC, Wes K0HPZ, 719-687-8758. E-Mail: w1w@prodigy.net
FL - SARASOTA - Computer Show. Municipal Auditorium. Frank Cox 941-954-0202

AUGUST 29

IL - WOODSTOCK - Hamfest. Tri-County Radio Group, Bob Grosse N9KXG, 708-944-0500. E-Mail: N9KXG@quality-enterprises.com Web: http://quality-enterprises.com/torg/
PA - NEW KENSINGTON - Swap/Flea Market. Skyview Radio Society Club House. Bob 724-727-2194
TN - LEBANON - Hamfest. Short Mountain Repeater Club, Patsy Pierce K3PAT, 615-395-4488.

SEPTEMBER 1999

SEPTEMBER 4

CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052
CANADA - ONTARIO - CARP - Hamfest. Ottawa ARC, Jim Cummings VE3XJ, 613-446-1225. E-Mail: fleamarket@oarc.net Web: http://oarc.net/fleamarket
NM - ALAMOGORDO - Hamfest. Otero County Fairgrounds, US 54 & Fairgrounds Rd. VEC testing. Alamogordo ARC, Larry Moore WA5UNO, 505-437-0145
PA - UNIONTOWN - Hamfest. Uniontown ARC, Carl Chuprinko WA3HQK, 304-594-3779

SEPTEMBER 4-5

NC - SHELBY - Hamfest. Shelby ARC. John Ledford N4GOQ, 704-482-4507. E-Mail: n4goq@shelby.net Web: http://www.shelby.net/n4fan

SEPTEMBER 10-11

AR - MENA - Hamfest. Queen Wilhelmina Hamfest Assn., Charlotte Lee KC5DOR, E-Mail: blee@ipa.net. Ray Lively W5DLC, 903-764-5599, E-Mail: raysoft@intrastar.net

SEPTEMBER 11

AR - MOUNTAIN HOME - Hamfest. Twin Lakes ARC, Miles Waldron N5QMI, 870-492-4466. E-Mail: mpwaldron@centuryinter.net
CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves
DE - DOVER - Hamfest. Kent County ARC, Larry Roll K3LT, 302-678-4841. E-Mail: yodoc@aol.com or k3lt@magpage.com
IN - SPENCER - Hamfest. Owen County ARA, Kathryn Smith K9INU, 812-829-2140
ME - WINDSOR - Hamfest. Fairgrounds. AARA, Frank N1ITR, 207-623-9217
MN - RUSH CITY - Hamfest. East Central MN ARC, Larry Jilek KA0MEN, 320-358-4205
MO - COLUMBIA - Hamfest. Good Time Country, 5551 S. Hwy. 63. 8am-2pm. VE Exams. Central Missouri Radio Assn., Bruce Odle, 3315 Berrywood Dr., Ste. 101, Columbia, MO 65201
NY - BALLSTON SPA - Hamfest. County Fairgrounds. 7am-3pm. VEC Exams. Talk-in: WA2UMX 146.40/147.00 & 147.84/147.24. Saratoga County RACES Assn., Darlene Lake N2XQG, 518-587-2385 E-Mail: lake@capital.net
PA - ERIE - Hamfest. Franklin Twp. Firehall. VE Exams, 9am, Franklin Center Methodist Church, Rt. 98. Talk-in: 146.01/61. Radio Assn. of Erie, Dr. Tom McClain N3HPR, 814-833-1640. E-Mail: TEM@ERIE.NET Web: http://www.erie.net/~n3ntj/hamfest.htm
WA - GRAHAM - Tacoma Electronics Fleamarket. (Pierce County Fairgrounds), Frontier Park, 21718 Meridian Ave. E. 9am-3pm. Talk-in: 147.38+ PL 103.5, simplex 146.58. RCT, Roger 253-475-4293. E-Mail: rtwig@worldnet.att.net Web: www.mashell.com/~roblee/rct.htm

SEPTEMBER 11-12

FL - MELBOURNE - Hamfest. Auditorium. Platinum Coast ARC, Tim Madden KI4TG. E-Mail: ki4tg@msn.com
KY - LOUISVILLE - ARRL KY State Convention. Bullit County Fairgrounds, I-65 (South 25 min.). Greater Louisville Hamfest Assn., Herbert Rowe W4WQD. 812-282-7007 or 812-948-0037 (commercial), 502-935-7197 or 606-284-9090 (FleaMkt/TailGate) E-Mail: wd4ixl@juno.com Web: http://www.thepoint.net/~glha/

SEPTEMBER 12

DE - FELTON - Hamfest. Kent County ARC, Larry Roll K3LT, 302-678-4841. E-Mail: W3HZW@hotmail.com
IL - JOLIET - Hamfest. Bolingbrook ARS, Marti Barton KA9ZJJ, 815-436-0559. E-Mail: mkbarton@flash.net
MA - SOUTH DARTMOUTH - Hamfest. At club. SE MA ARA, Bill K1IBR, 508-996-2969
OH - FINDLAY - Hamfest. Hancock County Fairgrounds. Talk-in: 147.15+, 444.15. Findlay RC, Bill Kelsey N8ET, 419-423-4604. E-Mail: kanga@bright.net Web: http://www.bright.net/~kanga/w8ft/
PA - BUTLER - Hamfest. Butler County ARA, Gerald Wetzel W3DMB, 724-282-6777 E-Mail: w3dmb@aol.com Web: http://www.nauticom.net/www/cliff/bcara

SEPTEMBER 17

NJ - PISCATAWAY - Ham & Electronics Auction. North Stelton Firehouse, Haines Ave. E of Stelton Rd. 6pm. Piscataway ARC, Marty 732-396-1836 (before 9pm)

SEPTEMBER 18

AR - LITTLE ROCK - Hamfest. CAREN, Scott Derden K5SCD, 501-834-1881 E-Mail: sderden@flash.net Web: http://carenclub.webjump.com
CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052
IL - ROLLING MEADOWS - W9DXCC Convention. Northern Illinois DX Assn., Bill Smith W9VA, 847-945-1564 E-Mail: w9va@aol.com Web: http://www.qth.com/w9dxcc
KY - CAVE CITY - Hamfest. Convention Center. VE Exams. The Southern KY DX Assn., Larry Brumett KN4IV, 502-651-2363. E-Mail: lbrumett@glasgow-ky.com Web: http://www.geocities.com/CapitolHill/5421
MA - MARSHFIELD - Hamfest. Fairgrounds, Rt. 3A. Genesis ARS, Lou N1WNT, 781-837-6651. E-Mail: n1wnt@mediaone.net Web: http://home.ici.net/~marsfair/marsfair.html
ME - LINCOLN - Hamfest. Burr School. VE testing. Bagley ARC, Sylvia N1JNR, 207-732-5185.
MI - GRAND RAPIDS - Hamfest. Grand Rapids ARA, Ed Novakowski N8UXN, 616-458-9029. E-Mail: barbv@voyager.net Web: http://www.w8dc.org
MI - MT. CLEMENS - Hamfest. L'Anse Creuse ARC, John Slobodnik N8NXW, 810-791-4484 or 810-757-8192 Ext. 151, E-Mail: irish12@juno.com Betty McGinn N8SIH, 810-791-4484, E-Mail: boops@juno.com Web: http://www.flash.net/~lcarc/
NY - HAMBURG - Western NY ARRL Section Convention. Harold Smith K2HC, 716-424-7184 E-Mail: info@buffalohamfest.org Web: http://www.buffalohamfest.org
NY - MARGARETVILLE - Hamfest. Margaretville ARC, Harold Murken NQ2Y, 914-586-3893. E-Mail: bourke@catskill.net
PA - SCHNECKSVILLE - Hamfest. Fire Dept. on PA Rt. 309. Talk-in: 146.70 (PL 151.4)/R, 444.90 (PL 151.4)/R. DLARC, William Goodman K3ANS, 610-258-5063. E-Mail: aa3ix@arrl.net Web: http://www.kutztown.edu/faculty/chuk/dlarc/
RI - FORESTDALE - Flea Market and Auction. VFW, Rt. 146. Rhode Island Amateur FM Repeater Service, Rick Fairweather K1KYI, 401-725-7507. E-Mail: k1kyi@juno.com
TX - WEBSTER - Hamfest. Clear Lake ARC, Bob Biekert KA5GLX, 281-488-2913 E-Mail: ka5glx@clarc.org Web: http://www.clarc.org

SEPTEMBER 18-19

IL - PEORIA - Hamfest. Peoria Area ARC, Jim Williams N9HHU, 309-692-3378. Fax: 309-698-8643. E-Mail: jimeoc@worldnet.att.net or jimn9hhu@juno.com Web: http://www.w9uvi.org
TX - EL PASO - International Hamfiesta. Craig Lyles KC7UXM, 915-821-7501
VA - VIRGINIA BEACH - Hamfest and VA State ARRL Convention. Pavilion. Sat: 9am-5pm, Sun: 9am-4pm. Talk-in: 146.970. Manny Steiner K4DOR, 757-HAM-FEST. E-Mail: HAMFEST@EXIS.NET or Lewis B. Steingold W4BLO, 757-486-3800 Web: WWW.VAHAMFEST.COM

SEPTEMBER 19

CT - NEWTOWN - Hamfest. Edmond Town Hall, Rt. 6. 9am-2pm. Talk-in: 146.67. Candlewood ARA, Jeff Cantor WB3DLG, 203-798-6860. E-Mail: wb3dlg@earthlink.net Web: http://www.danbury.lib.ct.us/org/cara/
MA - CAMBRIDGE - Flea at MIT. Albany and Main Sts. 9am-2pm. Talk-in: 146.52 & 449.725/444.725 W1XM/R PL 114.8 (2A). Nick Altenbernd KA1MQX, 617-253-3776 (9-5). Web: http://web.mit.edu/w1mx/www/swapfest.html
MI - ADRIAN - Hamfest. Lenawee County Fairgrounds. VE Exams. Adrian ARC, Brian Sarkisian KG8CO, 517-265-1537. E-Mail: kg8co@lni.net Web: http://www.lni.net/~w8tqe
NJ - TRENTON - Hamfest. Tall Cedars of Lebanon picnic grove, Sawmill Rd. Talk-in: 146.67-. Delaware Valley Radio Assn., Darryl Foyuth N2JVP, 609-882-2240. E-Mail: n2jvp@amsat.org Web: www.slac.com/w2zq
NY - BETHPAGE - Long Island Hamfair. Briarcliffe College, 1055 Stewart Ave. 8:30am-2pm. VE Exams. Talk-in: W2VL 146.85 repeater (136.5PL). Long Island Mobile ARC, Rich N2WJL, 516-520-9311. E-Mail: hamfest@limarc.org Web: http://www.limarc.org
OH - CINCINNATI - Hamfest. Kolping Center. 8am-4pm. Greater Cincinnati ARA, Jim Weaver K8JE, 513-825-2868. E-Mail: JimWeaver@aol.com Tom Denham K8VOE, 513-779-3951. E-Mail: tdenham@eos.net
PA - YORK - Hamfest. York County Area Vocational Technical School, Queen St. (Exit 6E off I-83). 8am-3pm. York Hamfest, 717-764-8193 (ph/fax). E-Mail: W3SST@juno.com Web: http://www.yorkhamfest.org

SEPTEMBER 24-25

MI - FLINT - State Convention. University of MI-Flint Riverfront Campus. Tuscola County ARA & Bay Area ARA, Val Rose N8EXV, 810-607-7732. E-Mail: n8exv@yahoo.com

SEPTEMBER 24-25-26

NH - LANCASTER - Super Moose Festival. Lancaster Fairgrounds, Rt. 3. The United Way of Northern NH, 603-752-3343. E-Mail: unitdway@ncia.net

SEPTEMBER 25

AL - MOBILE - Hamfest. Mobile ARC, Tommy Thompson KC4OLV, 334-653-9239 or 334-431-2019. E-Mail: kc4olv@zebra.net Web: http://www.angelfire.com/al/marc3/
FL - DAYTONA BEACH - Hamfest. Embry Riddle Aeronautical University Campus, Clyde Morris Blvd. 9am-5pm. ARRL Exams. Talk-in: 147.150 +600. DBARA, E-Mail: munseyj@mindspring.com Web: http://www.america.com/~dbara/ or http://www.db.erau.edu/campus/student/club/erara
NJ - MT. HOLLY - Hamfest. South Jersey Radio Assn. Joseph Cramer N2XYZ, 609-268-2135.

Continued on page 61

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> 16m Ram / 1m Video / 32 Bit Local Bus 486-50 Mhz & Math Co-processor, 28.8k Modem (Internet Ready)
> Long Lasting Hydride Battery ($150 Value)
> Sound & Microphone, External Mini 3.5 Floppy
> 8.25" Display-64 Shade Monochrome REFLECTIVE
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OSCILLOSCOPES & ACCESSORIES

OSCILLOSCOPES

TEK 2445 150 MHz 4-channel Oscilloscope	$1,400.00
TEK 2465 300 MHz 4-channel Oscilloscope	$2,250.00
TEK 7104 1 GHz 2-Channel Oscilloscope, w/7A29,7A29-04,7B10,7B15	$3,000.00
TEK 7844 400 MHz Dual Beam Oscilloscope with 7A24,7A26,7B80,7B85	$900.00
TEK 7904 500 MHz Oscilloscope, with 7A24, 7A26, 7B80, 7B85	$900.00
TEK SC502 15 MHz Dual Trace Oscilloscope, TM500 series	$325.00
TEK SC503 10 MHz Dual Trace Storage Oscilloscope, TM500 series	$375.00

PROBES

HP 1122A Probe Power Supply	$150.00
HP 54701A 2.5 GHz 10X FET Probe, for 54700 series oscilloscopes	$1,000.00
TEK 1101A Accessory Power Supply, for FET probes	$200.00
TEK P6015A 75 MHz 40 kVpk 1000X Probe	$600.00
TEK P6046 100 MHz Differential Probe	$500.00
TEK P6150 9 GHz 10X/ 3 GHz 1X 50 Ohm Probe, SMA(m) output	$400.00
TEK P6201 900 MHz 1X/10X/100X FET Probe	$450.00
TEK P6202A 500 MHz 10X FET Probe	$250.00
TEK P6701-opt.02 O/E Converter, 450-1050 nm/0-1 mW: DC-700 MHz, ST conn.	$175.00

CALIBRATION

TEK SG503 Level Generator, 250 kHz-250 MHz, TM500 series	$600.00

WAVEFORM GENERATORS

FUNCTION

HP 3310B 5 MHz Function Generator, variable phase trigger	$350.00
HP 3312A 13 MHz Function Generator	$500.00
HP 3314A-001 20 MHz Function Generator, HPIB	$1,500.00
HP 3325A 21 MHz Synthesized Function Generator, HPIB	$1,000.00
HP 3325A-002 21 MHz Synthesized Function Generator, HV output option	$1,500.00
HP 8165A-002 Prog. Signal Source, 1 mHz-50 MHz, log sweep	$1,500.00
HP 8904A-001,002,004 Multifunction Synthesizer, DC-600 kHz	$2,500.00
TEK AWG5102 Arb.Waveform Gen., 20 MS/s,12 bits,50ppm synthesis <1MHz	$900.00
TEK AWG5105-opt.02 Arbitrary Waveform Generator, dual channel option	$1,250.00
TEK DD501 Digital Delay & Burst Gen., for function & pulse gen's	$275.00
TEK FG501 1 MHz Function Generator, TM500 series	$225.00
TEK FG502 11 MHz Function Generator, TM500 series	$300.00
TEK FG503 3 MHz Function Generator, TM500 series	$250.00
TEK RG501 Ramp Generator, TM500 series	$175.00
WAVETEK 288 20 MHz Synthesized Function Generator, GPIB	$750.00

PULSE

BERKELEY NUCLEONICS 7085B Digital Delay Generator, 0-100 mS, 1 nS res.,5 Hz-5 MHz	$750.00
HP 214B 10 MHz 100 Vpk Pulse Generator	$1,200.00
HP 8007B 100 MHz Pulse Generator	$650.00
HP 8012B 50 MHz Pulse Generator, variable transition time	$600.00
HP 8080A/81A/83A/84A 300 MHz Word Generator	$800.00
HP 8080A/91A/92A/93A 1 GHz Single Channel Pulse Generator	$950.00
HP 8112A 50 MHz Programmable Pulse Generator, HPIB	$4,000.00
HP 8115A 50 MHz Dual Channel Pulse Generator, HPIB	$2,750.00
HP 8116A-001 50 MHz Pulse / Function Generator, burst & log sweep	$3,900.00
TEK PG502 250 MHz Pulse Generator, Tr<1nS, TM500 series	$600.00
TEK PG505 100 kHz Pulse Generator, 80 V peak, TM500 series	$275.00
TEK PG508 50 MHz Pulse Generator, TM500 series	$500.00
WAVETEK 802 50 MHz Pulse Generator	$300.00

VOLTAGE & CURRENT

VOLTMETERS

FLUKE 845AR High Impedance Voltmeter / Null Detector	$400.00
HP 3456A 6-1/2 Digit Voltmeter, HPIB	$500.00
HP 3457A 7-1/2 digit Voltmeter, HPIB	$1,200.00
HP 3478A 5-1/2 digit Multimeter, HPIB	$600.00
KEITHLEY 181 6-1/2 digit Nanovoltmeter, 10 nV sensitivity, GPIB	$900.00
SOLARTRON 7081 8-1/2 digit Voltmeter	$3,250.00
TEK DM5010 4-1/2 digit Multimeter, TM5000 series plug-in	$300.00
TEK DM501A 4-1/2 digit Multimeter, TM500 series plug-in	$225.00

CALIBRATION

FLUKE 510A AC Reference Standard, 10 VRMS, 0-10 mA	$450.00
FLUKE 515A Portable Calibrator, DC/AC/Ohms, line & battery power	$900.00
FLUKE 5220A Transconductance Amplifier, DC-5 kHz, 0-20 A	$3,000.00
VALHALLA 2703 AC Volt.Std., 0-120V/10 Hz-100 kHz;120-1200V/10 Hz-1 kHz	$1,500.00

VOLTAGE SOURCES

HP 6114A Precision Dual Range Power Supply, 20 V 2 A/ 40 V 1 A	$850.00
HP 6115A Precision Dual Range Power Supply, 50V 0.8A / 100V 0.4A	$850.00
KEITHLEY 228 Programmable Voltage/Current Source	$1,900.00

CURRENT METERS & SOURCES

HP 4140B Picoammeter / DC Voltage Source, without test fixture	$2,000.00
HP 6177C DC Current Source, to 50 V, 500 mA	$500.00
HP 6181C DC Current Source, to 100 V, 250 mA	$500.00
HP 6186B DC Current Source, to 300 V, 100 mA	$300.00
HP 6186C DC Current Source, to 300 V, 100 mA	$750.00
KEITHLEY 225 Current Source, 0.1 uA-100 mA, 10-100 V compliance	$500.00
KEITHLEY 227 Current Source, 1 uA-1 A, 0-50 V compliance	$800.00
KEITHLEY 614 Electrometer	$650.00
TEK CT-5 High Current Transformer for P6021/A6302, to 1000A	$375.00
TEK P6022 AC Current Probe w/termination, 935 Hz-120 MHz, 6 A pk	$275.00

IMPEDANCE & COMPONENT TEST

L.C.R.

BOONTON 62AD 1 MHz Inductance Meter, 2-2000 uH	$550.00
BOONTON 72BD 1 MHz Capacitance Meter, 3-1/2 digit display	$650.00
HP 4262A-101 3-1/2 digit LCR Meter, 120 Hz/ 1 kHz/ 10 kHz test, HPIB	$1,500.00
HP 4280A-001 1 MHz C Meter / C-V Plotter; 5-1/2 digit res. C	$3,000.00

STANDARDS

E.S.I. SR-1 Standard Resistor, various values	$125.00
E.S.I. SR1010 Resistance Transfer Standards, 1 Ohm-100 K/step	$550.00
E.S.I. SR1050-1M Resistance Transfer Standard, 1 Megohm/step	$2,000.00
GR 1404-A 1000 pF Reference Standard Capacitor	$700.00
GR 1406 Standard Air Capacitors, GR900 connector, 0.1% acc.	$375.00
GR 1432-U 4-Decade Resistor, 0-111.10 Ohms, 0.01 Ohm resolution	$100.00
GR 1433-J 4-Decade Resistor, 0-11,110 Ohms, 1 Ohm resolution	$150.00
GR 1433-K 4-Decade Resistor, 0-1,110 Ohms, 0.1 Ohm resolution	$150.00
GR 1433-L 4-Decade Resistor, 0-111,100 Ohms, 10 Ohms resolution	$150.00
GR 1433-N 5-Decade Resistor, 0-11,111 Ohms, 0.1 Ohm resolution	$200.00
GR 1433-X 6-Decade Resistor, to 111,111.0 Ohms, 0.1 Ohm res.	$250.00

HI & LO RESISTANCE

HP 4328A Milliohmmeter	$1,200.00

T.D.R.

TEK 1502-opt.04 Time Domain Reflectometer, 0-2,000 feet, chart recorder	$1,400.00
TEK 1503B-03,04 T.D.R., 0-50,000 ft., chart recorder & battery power	$3,000.00
TEK 1503-opt.04 Time Domain Reflectometer, 0-50,000 feet,chart recorder	$1,400.00

POWER SUPPLIES

SINGLE OUTPUT

GLASSMAN PS/WH-03R150XE2 0-3000 V 0-150 mA CV/CC Power Supply	$800.00
HP 6011A Autoranging 0-20 V 0-120 A Power Supply, 1000 W max.	$1,400.00
HP 6032A 0-60 V/ 0-10 A/ 1000 W Autoranging System Supply, HPIB	$2,000.00
HP 6200B Dual Range Supply, 0-20 V 0-1.5 A/ 0-40 V 0-750 mA CVCC	$200.00
HP 6201B 0-20 V 0-1.5 A CV/CC Power Supply	$175.00
HP 6207B 0-160 V 0-200 mA CV/CC Power Supply	$200.00
HP 6256B 0-10 V 0-20 A CV/CC Power Supply	$250.00
HP 6263B 0-20 V 0-10 A CV/CC Power Supply	$400.00
HP 6266B 0-40 V 0-5 A CV/CC Power Supply	$400.00
HP 6267B 0-40 V 0-10 A CV/CC Power Supply	$550.00
HP 6269B-028 0-40 V 0-50 A CV/CC Power Supply; 230 VAC line	$900.00
HP 6274B 0-60 V 0-15 A CV/CC Power Supply	$650.00
HP 6281A 0-7.5 V 0-5 A CV/CC Power Supply	$150.00
HP 6282A 0-10 V 0-10 A CV/CC Power Supply	$200.00
HP 6289A 0-40 V 0-1.5 A CV/CC Power Supply	$200.00
HP 6299A 0-100 V 0-750 mA CV/CC Power Supply	$200.00
HP 6384A 4.0-5.5 V at 8 A CV/CL Power Supply	$125.00
HP 6443B 0-120 V 0-2.5 A CV/CC Power Supply	$450.00
HP 6672A System DC Power Supply, 0-20 V 0-100 A CV/CC, HPIB	$2,750.00
KEPCO ATE 36-30M 0-36 V 0-30 A CV/CC Power Supply	$900.00
KEPCO ATE 36-8M 0-36 V 0-8 A CV/CC Power Supply	$375.00
LAMBDA LK-352-FM 0-60 V 0-15 A CV/CC Power Supply	$600.00
SORENSEN DCR 20-25B2 0-20 V 0-25 A CV/CC Power Supply	$550.00
SORENSON DCR 300-1.25A 0-300 V 0-1.25 A CV/CC Power Supply	$400.00
SORENSON DCR 600-0.75B2 0-600 V 0-750 mA CV/CC Power Supply	$550.00
SORENSON DCR 600-1.5B 0-600 V 0-1.5 A CV/CC Power Supply	$700.00
SORENSON SRL 20-12 0-20 V 0-12 A CV/CC Power Supply	$400.00
SORENSON SRL 60-8 0-60 V 0-8 A CV/CC Power Supply	$600.00
TEK PS501-1 Power Supply, 0-20 V, 2 mV res., 400 mA, TM500 series	$175.00

MULTIPLE OUTPUT

HP 6205C Dual Power Supply, 0-40 V 300 mA & 0-20 V 600 mA, CV/CL	$300.00
HP 6228B Dual 0-50 V 0-1 A CV/CC Power Supply	$450.00
HP 6236B Triple Output Supply, to +/-20 V 0.5 A & 0-6 V 2.5 A	$375.00
HP 6237B Triple Output Supply, to +/-20 V 0.5 A & 0-18 V 1 A	$375.00
HP 6253A Dual 0-20 V 0-3 A CV/CC Power Supply	$450.00
HP 6255A Dual 0-40 V 0-1.5 A CV/CC Power Supply	$450.00
KEPCO MPS-620M Triple Output Supply, dual 0-20V 1A tracking & 0-6V 5A	$250.00
LAMBDA LPD-422-FM Dual 0-40 V 0-1 A CV/CC Power Supply	$300.00
LAMBDA LPT-7202-FM Triple Output Power Supply	$450.00
TEK PS5010 Programmable Triple Power Supply, TM5000 series	$650.00
TEK PS503A Dual Power Supply, TM500 series	$200.00

MISCELLANEOUS

ACME PS2L-500 Programmable Load, 0-75 V / 0-75 A / 500 Watts max.	$350.00
ELGAR 501C/400SD AC Power Source, 45 Hz-5 kHz, 500 VA, 0-135 VAC	$1,150.00
HP 59501B HPIB Isolated DAC/Power Supply Programmer	$175.00
HP 6825A Bipolar Power Supply/ Amplifier, +/- 20 V 2 A	$800.00
KEPCO BOP 20-20M Bipolar Op Amp/Power Supply, to 20 V 20 A	$675.00
KEPCO BOP 36-5M Bipolar Op Amp/Power Supply, to 36 V 5 A	$400.00
KEPCO BOP 50-2M Bipolar Op Amp/Power Supply, to 50 V 2 A	$400.00
TRANSISTOR DEVICES DAL-50-15-100 Programmable Load, 0-50 V, 0-15 A, 100 Watts max.	$200.00

TIME & FREQUENCY

UNIVERSAL COUNTERS

HP 5314A-001 100 MHz/100 nS Universal Counter; TCXO reference option	$275.00
HP 5315A-001 100 MHz/100 nS Universal Counter, TCXO reference option	$450.00
HP 5315A-002,003 100 MHz/100 nS Univ. Counter; batt. power & 1 GHz C-ch.	$650.00
HP 5315A-003 100 MHz/100 nS Univ. Counter, 1 GHz C-channel option	$550.00
HP 5315B 100 MHz/ 100 nS Universal Counter	$500.00
HP 5316A 100 MHz/100 nS Universal Counter, HPIB	$600.00
HP 5316A-001,003 100 MHz/ 100 nS Univ. Counter, HPIB, TCXO, 1 GHz C-ch.	$750.00
HP 5316B 100 MHz/ 100 nS Universal Counter, HPIB	$750.00
HP 5364A Microwave Mixer / Detector, for modulation domain an.	$3,000.00
HP 5370B 100 MHz/ 20 pS 11 digit Universal Time Interval Counter	$1,200.00
PHILIPS PM6672/411 120 MHz/100 nS Universal Counter, C-channel 70-1000 MHz	$450.00
TEK DC5004 Programmable 100 MHz/100nS Counter/Timer, TM5000 series	$250.00
TEK DC5009 Programmable 135 MHz Univ. Counter/Timer, TM5000 series	$400.00
TEK DC5010 350 MHz / 3.125 nS Universal Counter, TM5000 series	$950.00
TEK DC503A 125 MHz/100 nS Universal Counter, TM500 series	$275.00
TEK DC509 135 MHz/ 10 nS Universal Counter, TM500 series	$275.00

FREQUENCY COUNTERS

EIP 545A 18 GHz Frequency Counter	$750.00
EIP 575 18 GHz Source Locking Counter, GPIB	$1,250.00
FLUKE 7220A-010,131,351 1.3 GHz Counter; battery power, OCXO, and res. mult.	$500.00
HP 5340A 18 GHz Frequency Counter	$450.00
HP 5343A-001 26.5 GHz Frequency Counter, OCXO reference	$3,500.00
HP 5345A/5355A/5356B 26.5 GHz CW/Pulse Frequency Counter	$3,500.00

STANDARDS

HP 105B Quartz Oscillator, 0.1/ 1.0/ 5.0 MHz, battery power	$1,500.00
HP 5087A-opt.032 Distribution Amplifier, 12 outputs at 5 MHz	$1,750.00

AUDIO & BASEBAND

SPECTRUM ANALYSIS

HP 3586C Selective Level Meter, 50 Hz-32.5 MHz, 50 & 75 ohms	$1,200.00
TEK 7L5/L3/R7603 Spectrum Analyzer, 20 Hz-5 MHz, 10 Hz min. res.,w/frame	$1,500.00

DISTORTION ANALYZERS

HP 339A Distortion Analyzer, built-in low distortion osc.	$750.00
HP 8903A-001 Audio Analyzer, 20 Hz-100 kHz; rear panel input	$1,500.00
TEK DA4084 Programmable Distortion Analyzer	$750.00

RMS VOLTMETERS

FLUKE 8922A True RMS Voltmeter, 180 uV-700 V, 2 Hz-11 MHz	$450.00

OSCILLATORS

HP 3336C Synthesizer / Level Generator, 10 Hz-21 MHz	$1,000.00
TEK SG502 Sine/Square Osc., 5 Hz-500 kHz, 70 dB step atten.,TM500	$200.00

MISCELLANEOUS

HP 3575A-002 Phase-Gain Meter, 1 Hz-13 MHz, dual display	$850.00
KROHN-HITE 3103 High/Low Pass Filter, 10 Hz-3 MHz, 24 dB/octave	$350.00
KROHN-HITE 3202 Dual HP/LP/BP/BR Filter, 20 Hz-2 MHz, 24 dB/octave	$450.00

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KROHN-HITE 3342R Dual HP/LP Filter, 0.001 Hz-99.9 kHz, 48 dB/octave	$900.00
KROHN-HITE 3750 LP/HP/BP/BR Filter, 0.02 Hz-20 kHz, 6/12/18/24 dB/oct.	$600.00
KROHN-HITE DCA-10R 10 Watt Amplifier, 20 dB gain, DC-1 MHz, 600-1000 Ohms	$450.00
ROCKLAND 852 Dual Highpass/ Lowpass Filter, 0.1 Hz-111 kHz	$900.00
TEK AM502 Differential Amplifier, 0.1 Hz-1 MHz, TM500 series	$475.00

RF & MICROWAVE

SPECTRUM ANALYZERS

HP 11517A/18A/19A/20A Mixer Set, 12.4-40.0 GHz, for HP 8555A/8569A	$500.00
HP 11970A WR28 Harmonic Mixer, 26.5-40 GHz	$1,100.00
HP 11970K WR42 Harmonic Mixer, 18.0-26.5 GHz	$1,100.00
HP 11970Q WR22 Harmonic Mixer, 33-50 GHz	$1,400.00
HP 11970U WR19 Harmonic Mixer, 40-60 GHz	$1,400.00
HP 3585A Spectrum Analyzer, 20 Hz-40 MHz, 3 Hz min. res. bw.	$4,500.00
HP 8559A/853A-001 Spectrum An., 0.01-21 GHz, 1 kHz res.,w/rackmount frame	$3,750.00
HP 8565A-100 Spectrum Analyzer, 10 MHz-22 GHz, 100 Hz min. res.	$3,500.00
HP 8568B Spectrum Analyzer, 100 Hz-1.5 GHz, 10 Hz min. res.	$8,500.00
HP 8569B Spectrum Analyzer, 10 MHz-22 GHz, 100 Hz min.res.bw.	$7,500.00
TEK TR502 Tracking Generator, 0.1-1800 MHz, for 7L13/7L14	$950.00
TEK WM782V WR15 Harmonic Mixer, 50-75 GHz	$1,500.00

NETWORK ANALYZERS

HP 11650A Network Analyzer Accessory Kit, APC7	$600.00
HP 35676A Reflection/Transmission Test Kit, 5 Hz-200 MHz	$1,000.00
HP 8405A Vector Voltmeter, 1-1000 MHz	$450.00
HP 85020A Directional Bridge, 10-4300 MHz, N(f) test port	$650.00
HP 85027C Directional Bridge, 0.01-18 GHz, N(f) test port	$1,750.00
HP 85044A Reflection/Transmission Test Set, 300 kHz-3 GHz	$1,500.00
HP 85054A Type N Calibration Kit, for HP 8510 series	$1,800.00
HP 8756A Scalar Network Analyzer	$2,500.00
HP R85026A WR28 Detector, 26.5-40 GHz, for HP 8757 series	$1,200.00
WILTRON 560-98KF50 SWR Autotester, 10 MHz-20 GHz, for Wiltron 560 series	$1,800.00

SIGNAL GENERATORS

FLUKE 6060A Synthesized Signal Gen., 0.1-1050 MHz, 10 Hz res., GPIB	$1,900.00
FLUKE 6060A/AN Synthesized Signal Gen.,10 kHz-520 MHz, 10 Hz res.,GPIB	$1,500.00
FLUKE 6060B/AK Synthesized Signal Gen., 0.1-1050 MHz, 10 Hz res.	$1,900.00
GIGATRONICS 1018 Synthesized Signal Gen., 50 MHz-18 GHz, 1 MHz res.	$4,500.00
GIGATRONICS 600/6-12 Synthesized Source, 6-12 GHz, 1 kHz res., GPIB	$2,500.00
GIGATRONICS 840-18 Freq. Multiplier, 18-26 & 26-40 GHz outputs 0 dBm	$2,750.00
GIGATRONICS 875/50 Levelled Multiplier, x4, 50.0-75.0 GHz output, -3 dBm	$2,500.00
GIGATRONICS 875/86 Levelled Multiplier, 26.5-40.0 & 50.0-75.0 GHz outputs	$3,750.00
GIGATRONICS 900/2-8 Synthesized Signal/Sweep Gen., 2-8 GHz, 1 MHz res.,GPIB	$2,500.00
HP 11720A Pulse Modulator, 2-18 GHz, 80 dB on/off ratio	$450.00
HP 3335A Synthesizer / Level Generator, 200 Hz-81 MHz	$4,500.00
HP 85100V Frequency Mult., 10-15 GHz in / 50-75 GHz out >0 dBm	$3,750.00
HP 8640B Signal Generator, 0.5-512 MHz, AM, FM, pulse modulation	$950.00
HP 8656B-001 Synth. Signal Gen., 0.1-990 MHz, 10 Hz res., OCXO ref.	$2,500.00
HP 8657A-002 Signal Generator, 0.1-1040 MHz, 10 Hz res., HPIB	$3,250.00
HP 8660C/86602B-002 Synth. Sig. Gen., 1-1300 MHz, FM / Phase mod. w/86635A	$2,750.00
HP 8660C/86603A Synthesizer, 1-2600 MHz, AM / FM, w/86633B	$3,250.00
HP 8672A Synthesized Signal Generator, 2-18 GHz, +3 dBm output	$6,000.00
HP 8673D Synth.Signal Generator, 50 MHz-26 GHz, AM/FM/Pulse	$18,500.00
HP 8673E Synthesized Signal Generator, 2-18 GHz, +8 dBm output	$9,500.00
HP 8673G-004,008 Synth. CW Signal Generator, 2-26 GHz, >+8 dBm output	$12,500.00
HP 8684B Signal Generator, 5.4-12.5 GHz, AM/ WBFM/ Pulse	$3,500.00
P.T.S. 250 Frequency Synthesizer, 1-250 MHz, 1 Hz res., +13 dBm	$750.00

SWEEP GENERATORS

HP 8350A/83545A-002 Sweep Oscillator, 5.9-12.4 GHz, 70 dB step attenuator	$4,000.00
HP 8601A Generator/Sweeper, 0.1-110 MHz, +20 dBm levelled	$400.00
HP 8620C Sweep Oscillator Frame	$550.00
HP 86222B-002 RF Plug-in, 10-2400 MHz, +13 dBm levelled, 70 dB atten.	$1,250.00
HP 86230B RF Plug-in, 1.8-4.2 GHz, +10 dBm unlevelled	$375.00
HP 86240C RF Plug-in, 3.6-8.6 GHz, +16 dBm levelled	$700.00
HP 86241A-001 RF Plug-in, 3.2-6.5 GHz, +8 dBm levelled	$300.00
HP 86242D-004,008 RF Plug-In, 5.9-9.0 GHz, +10 dBm levelled	$300.00
HP 86245A-001 RF Plug-in, 5.9-12.4 GHz, +17 dBm levelled	$600.00
HP 86250D RF Plug-in, 8.0-12.4 GHz, +10 dBm levelled	$500.00
HP 86260A RF Plug-In, 12.0-18.0 GHz, +10 dBm unlevelled	$500.00
HP 86260A-H04 RF Plug-in, 10.0-15.0 GHz, +10 dBm unlevelled	$500.00
HP 86290A-004 RF Plug-in, 2.0-18.0 GHz, +7 dBm levelled, rear output	$1,750.00
HP 86290B-004 RF Plug-in, 2.0-18.6 GHz, +10 dBm levelled, rear output	$1,850.00
WAVETEK 962 Sweep Generator, 1.0-4.0 GHz, markers, +12 dBm unlvld.	$1,250.00
WILTRON 6647M Sweep Generator, 10 MHz-20 GHz, +10 dBm levelled	$4,500.00

POWER METERS

ANRITSU MP-81B/ML-83A Power Meter, 75-110 GHz (WR10), -20 to +20 dBm	$2,500.00
BOONTON 4200-01A,03/&-4A x2 Dual Channel Microwattmeter, w/(2) 1 MHz-7 GHz sensors	$950.00
BOONTON 42B/41-4E Analog Power Meter, with 1 MHz-18 GHz sensor	$450.00
HP 435B/8481A Power Meter, -30 to +20 dBm, 10 MHz-18 GHz	$900.00
HP 435B/8482H Power Meter, -10 to +34 dBm, 100 kHz-4.2 GHz	$900.00
HP 436A/8481A Power Meter, -30 to +20 dBm, 10 MHz-18 GHz	$1,400.00
HP 8477A Power Meter Calibrator, for HP 432 series	$500.00
HP K486A WR42 Thermistor Mount, 18.0-26.5 GHz, for 432 series	$350.00
HP Q8486A Power Sensor, 33.0-50.0 GHz, WR22, for 435/6/7/8	$1,500.00
HP R486A WR28 Thermistor Mount, 26.5-40 GHz, for 432 series	$350.00
HP R8486A WR28 Power Sensor, 26.5-40 GHz, for HP 435/6/7/8	$1,500.00

RF MILLIVOLTMETERS

BOONTON 92B-opt.05 RF Millivoltmeter, 10 kHz-1.2 GHz, 75 Ohms scale	$500.00
RACAL 9303 TRMS Level Meter, 10 kHz-2 GHz, -77 to +23 dBm, GPIB	$875.00

AMPLIFIERS, MISCELLANEOUS

AMPLIFIER RES. 1W1000 Amplifier, 30 dB gain, 1-1000 MHz, 1 Watt output	$500.00
BOONTON 82AD-opt.01A Modulation Meter, AM, FM, 10-1200 MHz, GPIB	$750.00
ENI 1040L Amplifier, 55 dB gain, 10-500 kHz, 400 Watts	$2,750.00
HP 11729C-130,140 Carrier Noise Test Set, AM Noise & Rear Panel Inputs	$9,500.00
HP 415E SWR Meter	$200.00
HP 465A Amplifier, 20/40 dB, 5 Hz-1 MHz, 1/2 Watt/50 Ohms	$125.00
HP 8406A Comb Generator, 1/ 10/ 100 MHz increments, to 5 GHz	$500.00
HP 8447A Amplifier, 20 dB, 0.1-400 MHz, 5 dB NF, +6 dBm output	$375.00
HP 8447E Amplifier, 22 dB, 0.1-1300 MHz, +13 dBm output	$750.00
HP 8901A Modulation Analyzer, 150 kHz-1300 MHz	$2,500.00
HP 8901B-1,2,3 Modulation An., 0.15-1300 MHz, rear input, OCXO, ext.LO	$3,000.00
HP 8970A Noise Figure Meter	$4,000.00
HUGHES 1077H12F000 TWT Amplifier, 30 dB gain, 26.5-40 GHz, 1 Watt output	$5,000.00
ROHDE & SCHWARTZ ESH2 Test Receiver, 9 kHz-30 MHz	$5,000.00

COAXIAL & WAVEGUIDE

AMERICAN NUCLEONICS AM-432 Cavity Backed Spiral Antenna,LHC, 2-18 GHz,TNC(f) *NEW*	$95.00
AVANTEK AMT-400X2 WR28 Active Doubler, 13-20 GHz +10 dBm in, +10 dBm out	$450.00
BAYTRON 3-28-300/10 WR28 Directional Coupler, 10 dB, 26.5-40 GHz	$300.00
BIRD 4410A/4410-3 Wattmeter, 2-30 MHz, 10 W - 1 kW f.s., N(f/f)	$400.00
BIRD 6735-300 1 kW Load, 25-1000 MHz, LC(f), with wattmeter	$650.00
BIRD 8201 500 Watt Oil Cooled Load, DC-2.5 GHz, N(f)	$350.00
CONTINENTAL MW. RAE28-K-M WR28 x K(m) Endfire Adapter	$225.00
FXR/MICROLAB S3-02N Triple Stub Tuner, 200-1000 MHz, 100 Watts max., N(m/f)	$125.00
FXR/MICROLAB SL-03N Stub Tuner, 0.3-6.0 GHz, 100 Watts max., N(m/f)	$75.00
GR 874-LTL Constant Impedance Trombone Line, 0-44 cm, DC-2 GHz	$400.00
HP 11590A-001 Bias Network, 1.0-18.0 GHz, APC7	$450.00
HP 11636A 2-Way Power Divider, DC-18 GHz, N(m/f/f)	$300.00
HP 11692D Dual Directional Coupler, 22 dB, 2-18 GHz	$800.00
HP 33321K Programmable Step Atten., 0-70 dB, DC-26.5 GHz, 3.5mm	$475.00
HP 33327L-006 Programmable Step Attenuator, 0-70 dB, DC-40 GHz, 2.9mm	$1,000.00
HP 774D Dual Directional Coupler, 20 dB, 215-450 MHz	$275.00
HP 777D Dual Directional Coupler, 20 dB, 1.9-4.1 GHz	$275.00
HP 778D-011 Dual Dir. Coupler, 20 dB, 100-2000 MHz, APC7 test port	$450.00
HP 8431A 2-4 GHz Band Pass Filter, N(m/f)	$150.00
HP 8493C-003 3 dB Attenuator, 2 Watts, DC-26.5 GHz, APC3.5	$150.00
HP 8493C-020 20 dB Attenuator, 2 Watts, DC-26.5 GHz, APC3.5	$150.00
HP 8494G-002 Programmable Step Attenuator, 0-11 dB, DC-4 GHz, SMA	$350.00
HP 8495H-002 Programmable Step Attenuator, 0-70 dB, DC-18 GHz, SMA	$400.00
HP 8497K-004 Programmable Step z Attenuator, 0-90 dB, DC-26.5 GH	$750.00
HP K382A WR42 Direct Reading Attenuator, 0-50 dB, 18-26.5 GHz	$2,900.00
HP K422A WR42 Flat Broadband Detector, 18.0-26.5 GHz	$350.00
HP K532A WR42 Frequency Meter, 18.0-26.5 GHz	$450.00
HP K870A WR42 Slide Screw Tuner, 18.0-26.5 GHz	$275.00
HP K914B WR42 Moving Load, 18.0-26.5 GHz	$300.00
HP Q752D WR22 Directional Coupler, 20 dB, 33-50 GHz	$650.00
HP R382A WR28 Direct Reading Attenuator, 0-50 dB, 26.5-40 GHz	$2,000.00
HP R422A WR28 Crystal Detector, 26.5-40 GHz	$400.00
HP R532A WR28 Frequency Meter, 26.5-40 GHz	$500.00
HP R752C WR28 Directional Coupler, 10 dB, 26.5-40 GHz	$450.00
HP R752D WR28 Directional Coupler, 20 dB, 26.5-40 GHz	$450.00
HP R914B WR28 Moving Load, 26.5-40 GHz	$250.00
HP V365A WR15 Isolator, 25 dB, 50-75 GHz	$750.00
HP V752D WR15 Directional Coupler, 20 dB, 50-75 GHz	$650.00
HP X870A WR90 Slide Screw Tuner	$150.00
HUGHES 45712H-1000 WR22 Frequency Meter, 33-50 GHz	$900.00
HUGHES 45714H-1000 WR15 Frequency Meter, 50-75 GHz	$900.00
HUGHES 45716H-1000 WR10 Frequency Meter, 75-110 GHz	$900.00
HUGHES 45721H-1000 WR28 Direct Reading Attenuator, 0-50 dB, 26.5-40 GHz	$900.00
HUGHES 45724H-1000 WR15 Direct Reading Attenuator, 0-50 dB, 50-75 GHz	$1,000.00
HUGHES 45732H-1200 WR22 Level Set Attenuator, 0-25 dB, 33-50 GHz	$250.00
HUGHES 45772H-1100 WR22 Thermistor Mount, -20 to +10 dBm, 33-50 GHz	$400.00
HUGHES 45775H-1100 WR12 Thermistor Mount, -20 to +10 dBm, 60-90 GHz	$800.00
HUGHES 47316H-1111 WR10 Tuneable Detector, 75-110 GHz, positive polarity	$600.00
HUGHES 47741H-2310 WR28 Phase Locked Gunn Osc., 32.000 GHz, +18 dBm	$2,000.00
HUGHES 47742H-1210 WR22 Phase Locked Gunn Osc., 42.000 GHz, +18 dBm	$2,750.00
HUGHES 47974H-1000 WR15 SPST PIN Switch, 250 MHz speed, 60-62 GHz response	$375.00
KRYTAR 2616S Directional Detector, 1.7-26.5 GHz, K(f/m)/SMC	$200.00
M/A-COM 3-19-300/10 WR19 Directional Coupler, 10 dB, 40-60 GHz	$450.00
MICA C-121S06 Circulator, 17.5-24.5 GHz, SMA(f/m/m)	$75.00
MIDWEST MICROWAVE 3537 DC Block, 0.1-12.4 GHz, SMA(m/f) *NEW*	$40.00
MINI-CIRCUITS ZFDC-20-4 Directional Coupler, 19.5 dB, 1-1000 MHz, SMA(f)	$25.00
NARDA 3000-SERIES Directional Couplers	$150.00
NARDA 3024 Bi-Directional Coupler, 20 dB, 4-8 GHz	$300.00
NARDA 3090-SERIES Precision High Directivity Couplers	$225.00
NARDA 368BNM Coaxial High Power Load, 500 Watts, 2.0-18 GHz, N(m)	$500.00
NARDA 3752 Coaxial Phase Shifter, 0-180 deg./GHz, 1-5 GHz	$1,000.00
NARDA 3753B Coaxial Phase Shifter, 0-55 deg./GHz, 3.5-12.4 GHz	$1,000.00
NARDA 4000-SERIES SMA Miniature Directional Couplers	$75.00
NARDA 4226-10 Directional Coupler, 10 dB, 0.5-18.0 GHz, SMA(f)	$275.00
NARDA 4227-16 Directional Coupler, 16 dB, 1.7-26.5 GHz, 3.5mm(f)	$325.00
NARDA 4242-20 Directional Coupler, 20 dB, 0.5-2.0 GHz, SMA(f)	$100.00
NARDA 4247-20 Directional Coupler, 20 dB, 6.0-26.5 GHz, 3.5mm(f)	$200.00
NARDA 4247B-10 Directional Coupler, 10 dB, 6.0-26.5 GHz, 3.5mm(f)	$200.00
NARDA 5070-SERIES Precision Reflectometer Couplers	$300.00
NARDA 562 DC Block, 10 MHz-12.4 GHz, 100 V max., N(m/f)	$65.00
NARDA 765-10 10 dB Attenuator, 50 Watts, DC-5 GHz, N(m/f)	$165.00
NARDA 768-10,-20 10 dB or 20 dB Attenuator, 20 Watts, DC-11 GHz, N(m/f)	$120.00
NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz	$375.00
NARDA 794FM Direct Reading Variable Attenuator, 0-40 dB, 4-8 GHz	$375.00
OMNI-SPECTRA 2085-6010-00 Crystal Detector, 1-18 GHz, negative polarity, SMA(m/f)	$50.00
PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz	$250.00
SONOMA SCIENTIFIC 21A3 WR42 Circulator, 20 dB, 20.6-24.8 GHz	$75.00
TRG B510 WR22 Direct Reading Attenuator, 0-50 dB, 33-50 GHz	$1,000.00
TRG B528 WR22 Direct Reading Phase Shifter, 0-360 deg.,33-50 GHz	$1,250.00
TRG V551 WR15 Frequency Meter, 50-75 GHz	$600.00
TRG W551 WR10 Frequency Meter, 75-110 GHz	$750.00
WAVELINE 100080 WR28 Terminated Crossguide Coupler, 30 dB	$200.00
WEINSCHEL DS109 Double Stub Tuner, 1-13 GHz, N(m/f)	$150.00
WEINSCHEL DS109LL Double Stub Tuner, 0.2-2.0 GHz, N(m/f)	$150.00

COMMUNICATIONS

HP 3780A Pattern Generator / Error Detector, 1 kb/s - 50 Mb/s	$1,000.00
HP 4935A-001 Transmission Test Set, 20 Hz-110 kHz, battery option	$700.00
HP 59401A HPIB Bus Analyzer	$400.00
TEK 1410R NTSC Gen., w/SPG2 sync. generator, TSG7 color bars	$800.00
TEK 1411R PAL Gen.,w/SPG12 sync; TSG11 color bars;TSG13 linearity	$750.00
TEK 1411R PAL Test Gen., w/SPG12,TSG11,TSG13,TSG15,TSG16	$1,000.00
TEK 1411R PAL Test Gen., w/SPG12,TSG11,TSG12,TSG13,TSG15,TSG16	$1,100.00
TEK 1411R-opt.04 PAL Test Gen., w/SPG12,TSG11,TSP11,TSG13,TSG15,TSG16	$1,400.00
TEK 147A NTSC Test Signal Generator, with noise test signal	$800.00
TEK 148 PAL Insertion Test Signal Generator	$700.00
TEK 520A NTSC Vectorscope	$750.00
TEK 521A PAL Vectorscope	$750.00

MISCELLANEOUS

FLUKE 2180A RTD Digital Thermometer	$500.00
HP 7090A Measurement Plotting System	$1,500.00
P.A.R. 5206-95,98 Two-Phase Lock-In Amp., 2 Hz-100 kHz, GPIB	$1,500.00
TEK TM5006 5000-series 6-slot Programmable Power Module	$600.00
TEK TM504 500-series 4-slot Power Module	$175.00
TEK TM506 500-series 6-slot Power Module	$250.00
TEK TM515 500-series 5-slot Traveller Power Module	$275.00

Write In 43 on Reader Service Card.

Questions & Answers

TECH FORUM

This is a READER TO READER Column. All questions AND answers will be provided by *Nuts & Volts readers* and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and *NO GUARANTEES WHATSOEVER* are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

QUESTIONS

Send all material to **Nuts & Volts Magazine**, 430 Princeland Court, Corona, CA 91719, OR fax to (909) 371-3052, OR E-Mail to **forum@nutsvolts.com**

I have a dead Motorola model 19032WNSSD bag phone. It indicates "No Service." Does anybody service these, or have data that might allow me to repair it?

The local cell phone company just sold me a new one, calling it unrepairable.

8991 **David Schoepf**
Marianna, FL

I have an IBM Thinkpad computer. The hard drive is missing and I cannot get into CMOS. Any suggestions how I can tell it that it has no hard drive and boot on a floppy?

Also, where can I find a hard drive?

8992 **Cliff**
Salem, OR

I have several used Commodore 64 floppy drives, the 1541. I would like to use them for data logging in a standard RS-232 port. Has anyone done this?

8993 **Gary Depietro**
Deltona, FL

I need a circuit that will operate on 120 VAC and will control up to a 1 hp 120 VAC motor?

Objective: To cycle this motor at any off/on (continuous) interval (selectable in 5 minute increments) up to 60 minutes. (Same time off as on.)

8994 **Dean Freeland**
Stoneville, NC

I have the LabTec CS-150 stereo computer speakers. I need the headphone plug for one wire to play the tape cassette or portable radio.

I also need another small headphone, this one connected to the right speaker from the left amp speaker. I need three in all.

8995 **Fran Armijo Jr.**
San Antonio, NM

I have a custom wound 9 VDC motor/generator that when in generation mode, will output up to 5 amps DC.

The purpose of the motor/generator is two-fold: **1)** To electric start a small gas engine; **2)** after engine kicks over and runs, the motor is now a generator.

While generating power restores the battery and/or capacitor, and also powers the "running" lights, and/or accessories, the lamps are to be ELs, approximately six-eight panels of various dimenion.

Can someone help me with the little data I provided; design a VERY compact, lightweight DC-AC inverter, as flat as possible, and no bigger than a cigarette pack? This is to be worn.

8996 **William Donald McNeal Jr.**
Philadelphia, PA

I have scrapped out several loads of computer boards and sent them to Denver, CO for the gold in them.

I was told that there is a place somewhere in the US that buys the programmable chips, cleans them up and reuses them.

Do you have any knowledge of a place like this?

8997 **L. M. Laird**
Ogallala, NE

I have a Pioneer PDR-05 CD recorder which uses only consumer audio blanks. I have seen what appears to be the same machine sold as a Fostex pro-model that uses any (consumer or computer) blanks.

Is there something I can do to the PDR-05 to use it as a pro audio machine?

8998 **Anonymous**

I need information on how to hook up a "Rustrak" model 288 strip chart recorder. It seems to be operational, but I don't know how to input a signal to it.

A current address for this company (a division of Gulton Industries) would be helpful, too.

8999 **Richard Flaws**
Oswego, IL

I know it may be a difficult product to locate, but I am in search of a dual socket7 motherboard, as I have two matched P-100 processors, and four matched 32 MB EDO SIMMs.

I would like to locate a motherboard for these items so I can build a small Linux box.

89910 **David Draper**
via Internet

I have a two-axis accelerometer that has an output of 2.5 VDC in the level state. In the pitched up state, the output will go to 2.812 VDC. In the pitched down state, the output will go to 2.188 VDC.

This is too small of a voltage swing for me to work with. What I have is a board that takes 0-5 VDC to drive a model air plane servo; 0 VDC full left, 5 VDC full right, and 2.5 VDC at center.

What can I do to increase the voltage swing without changing the 2.5 VDC center? Example: pitch up 3.5 VDC, pitch down 1.5 VDC?

89911 **David F. Jones**
via Internet

Recently, the 1.35-volt KX-625 battery failed in my Olympus OM-1 camera.

Since mercury batteries are no longer commonly available, I am wondering if anyone knows of an adaptive circuit I could use, perhaps with an externally mounted six- or nine-volt battery?

I am not so worried about appearance as function. (I understand some expensive commercial replacements use short-lived 1.5-volt silver oxide batteries which snap into some sort of voltage reducing circuit.) Any ideas?

89912 **Allan Souligny**
via Internet

Is there a way to connect a phone hand-set to a computer as to take the place of the microphone and speakers when making an Internet call? Something simple that could be built using RadioShack parts.

89913 **J. Kato**
Naples, FL

I am interested in experimenting with bio feedback on my computer. I need to monitor blood pressure and heartbeat.

I have seen probes that attach to the finger in hospitals. Would it be possible to create something along that line and interface it to my "O" scope on my computer? How? Where to start looking?

89914 **Dave Bell**
via Internet

Does anyone have information on some type of very small (size of a quarter) tracking transmitter that I can build or purchase to track my cat at night?

It should be on all the time and transmit some type of tone or beep that I can track with a small handheld directional radio. The range needs to be only 500 to 1,000 feet.

89915 **Vernon Miller**
via Internet

I have Caller ID, and there are a few callers that display Private or Out of Area. Most of those blocked calls are people trying to sell me

ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of $25.00 will be sent if your answer is printed.
- In most cases, only one answer per question will be printed.
- Your name, city, state, and E-Mail address, (if submitted by E-Mail), will be printed in the magazine, unless you notify us otherwise with your submission.
- Due to space limitations, we can not reprint the original questions with the answer. The question number and the issue it appeared in are printed above the answer.
- Unanswered questions from a past issue may still be responded to.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

QUESTION INFO

TO BE CONSIDERED FOR PUBLICATION

All questions should relate to one or more of the following:
1) Circuit Design 3) Problem Solving
2) Electronic Theory 4) Other Similar Topics

INFORMATION/RESTRICTIONS

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

HELPFUL HINTS

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address and Phone Number. Only your name will be published with the question, but we may need to contact you.

ANSWERS TO #59912 - MAY 1999

I need help to find a distributor for a stepper motor driver IC and other ICs for stepper motors.

#1 The SAA1027 by Signetics is an alternative stepper motor driver IC. I obtained mine through **Quality Kits**, Kingston Ontario, Canada **www.qkits.com**.

As an alternative, you might consider purchasing a kit, such as the Velleman K8005 stepper motor driver board. Information and purchasing can be obtained through Quality Kits, or through any Velleman distributor in the U.S.

Eric North
Kingston, Ontario, Canada

#2 There are not many distributors or manufacturers of stepper motor ICs, because unfortunately, many of these parts are rapidly becoming obsolete. This is due in part to the introduction of specialized motion ICs and the ability of low-cost micro-controllers to emulate the functions of these chips.

I have needed to use these parts myself to control both Unipolar and Bipolar stepper motors for robotic's projects. I appreciated the convenience of having only three control lines: STEP, DIRECTION, and BRAKE, to use a micro-controller to drive a stepper motor, thus saving many lines of code in the micro-controller software.

In your question to *Nuts & Volts*, the stepper motor power requirement, the type of stepper motor (Unipolar or Bipolar), and the precision and resolution was not specified for your application. This information is critical to determine the correct IC or PLD to use.

For example, if your application requires simple single-axis positioning or low-speed rotation of a gear or platform, then a Unipolar stepper motor chip such as the UCN5804 would be most appropriate for your application. For applications that require more torque or high speed, then a Bipolar stepper motor IC or "H-Bridge" should be used.

To control a stepper motor with increased resolution, the IC must be able to support half-step, as well as full-step control modes.

Finally, if your application requires high speed, precision positioning for robotics, multi-axis control, factory automation, and CNC applications, or all of the above, then you may need a more expensive motion IC or PLD with an encoder or tachometer feedback attached to your stepper motor.

These extra features are needed to perform closed-loop control of the stepper motor using velocity or acceleration profiles.

For driving high-current stepper motors, a power high-voltage high-current Darlington array, such as the ULN2803, can be added to the outputs of a stepper motor controller IC, to handle the large currents.

The use of clamping diodes or opto-isolation between the micro-controller and the stepper motor controller IC driver lines is required if the IC does not provide this protection; otherwise the micro-controller might sustain damage from "back" EMF caused by the collapse of stepper motor coil magnetic fields.

A new stepper motor controller IC which I find particularly interesting is the EDE1200 from E-Lab Digital Engineering, Inc. In addition to the stepper motor controller IC functions, this chip supports a self-clocking "RUN" mode.

E-Lab also sells a Power Transistor Kit (for use with motors which draw up to 10A (75W) per phase). I have not tried using this IC, since I only just discovered it during my latest survey, but its specs and price are similar to the UCN5804.

My latest research using the Web and reading data books on various types of stepper motor ICs, reveal the following sources, including part number, company name, and URL (if any). These are listed below for your convenience.

List of stepper motor controller IC sources:

UNIPOLAR ICs:

MicroSystems UCN5804, Allegro www.allegromicro.com/control/partnum1.htm
Motorola SAA1042 www.newark.com
E-Lab Digital Engineering, Inc., PDB3517/1 www.elabinc.com/ede1200.htm
ERICSSON www.ericsson.se/microe/pdf/Industri/3517.pdf

BIPOLAR ICs:

L297 ST **Microelectronics** sbtm.yonsei.ac.kr/data/1334.pdf
L297D ST **Microelectronics** sbtm.yonsei.ac.kr/data/1334.pdf
L298 ST **Microelectronics** sbtm.yonsei.ac.kr/data/1334.pdf
LMD18200 **National Semiconductor** wirz.com/motor/lmd18200.html
PBL3717/2 **ERICSSON** www.ericsson.se/microe/pdf/Industri/3717_2.pdf

MOTION CONTROL ICs:

MCX305 (single-axis) **Aurotek** www.robot.com.tw/mcx305.htm
MCX314 (multi-axis) **Aurotek** www.robot.com.tw/mcx314.htm

Daniel F. Ramirez
Amherst, NH

#3 There are two stepper motor controller ICs manufactured by E-Lab and available from **All Electronics Corp. http://www.allcorp.com** for $8.30 each.

The EDE1200 is for six-wire unipolar stepper motors and the EDE1204 is for four-wire bipolar stepper motors.

These are 5 VDC, 18-pin ICs designed to interface a logic-level signal to a stepper motor and can be self-clocked in the RUN mode or external-clocked in the STEP mode. Capable of half-stepping, directional control, continuous run and stepping rate changes while the motor is stepping.

The inputs are TTL/CMOS with TTL level outputs. Specifications and hook-up diagrams are included with the ICs.

You can contact All Electronics Corp. at the above listed Web URL, or via E-Mail at: **allcorp@allcorp.com**. Mailing address: **All Electronics Corp., P.O. Box 567, Van Nuys, CA 91408-0567**.

I have done business with this company in the past and recommend them.

Robert Turner
Via Internet

#4 The Hewlett Packard HCTL-1100 is a decent general-purpose controller, available through Newark Electronics and a host of other distributors that carry HP stuff. HP also makes some other related items, including incremental encoders and quadrature decoder/counter chips.

National Semiconductor and Allegro both make some nice chips for power applications, like motor control.

The following web sites are for distributors that carry motor control chips of some sort or another.

Mouser Electronics: www.mouser.com
Digi-Key: www.digikey.com
Newark Electronics: www.newark.com
Allied Electronics: www.allied.avnet.com

Mark Dobrosielski
Bradford, MA

#5 Unitrode Corp. makes three stepper motor control ICs, which are the UC1517, UC1717, and the UC3717 (10V-45V).

They might have other types available since I discovered these in the 1994 IC master.

The contact information for Unitrode Corp. is: **Unitrode Integrated Circuits Corp.**, 7 Continental Blvd., Merimack, NH 03054-0399. Phone: **603-424-2410** fax: 603-424-3460.

Dennis Gifford
Henagar, AL

something.

There are times that my work, or family living outside my area are trying to call me. That's when it would be nice to know it's them and not listen to those telemarketers.

Now I know that it is possible to get the caller info even though it's blocked or out of the area. I was told the 911 operator and Police can see it along with many government agencies.

How can I see it? Can I modify an existing unit to show all call information? Is it possible to build a device to be used with the Caller ID unit? Where can I find more information on the Caller ID system?

89916 — **Joe Reed**, **Charlotte, NC**

I have an Apollo inkjet printer. I keep getting an error message that says "out of paper." I have tried quite a few different things, but I can't get this thing to print on a 486 running Windows 95.

89917 — **Lou Baugh**, **via Internet**

I have a Dentron linear amplifier that is no longer in production. I fixed the problem that caused arcing between the plates of the variable capacitor, but they keep arcing. I tried to file them smooth, but they still arc, so I tried looking for another variable capacitor, to no avail.

Can you please lead me to a supplier of this Dentron variable capacitor #D-232-45?

It measures about 15-250 pF and is approximately 3" long (not including the shaft), about 2-1/2" wide, and 2- 3/4" high. I must assume that this was a stock item that Dentron used, but I can't find a source for this size and capacity.

89918 — **Ken Weger**, **Colfax, CA**

ANSWERS

ANS. TO #W69914 - JUNE 1999

I have a CGA monitor that I would like to turn into a parts tester. There are several testers that tie to an oscilloscope and do this job, using horizontal and vertical deflection. Has anyone ever designed one of these circuits?

It is not very practical to turn a CGA monitor into an "oscilloscope" with X-Y deflection. A CGA monitor — like a television — is a raster scanning device. The electron beam covers the screen by scanning at a high rate (15750 Hz) left to right, and at a slower rate (60 Hz) top to bottom.

It is practically impossible to drive the deflection with another signal because of the way the CRT is powered.

The CRT requires a high voltage to light the screen. The high voltage is generated by the inductive energy from the horizontal deflection. Basically, the energy that is used to deflect the electron beam across the screen is "recycled" during the retrace.

A flyback transformer takes the magnetic energy in the deflection yoke (that is released as the beam "flies back"), and converts it to tens of thousands of volts of electrical energy.

If you disable the horizontal scanning in order to drive the X-Y deflection yoke directly, you lose the high voltage, and the tube goes black. There are ways around this, but they usually end up costing a lot more than the results you get are worth. And, of course, if you don't know exactly what you are doing, you could contact some of that high voltage and really hurt yourself.

I would recommend that you find a used oscilloscope for a parts tester. Really old models with very low bandwidth will work fine for a curve tracer.

Tim Godfrey
Via Internet

ANSWERS TO #6995 - JUNE 1999

I need a computer program that enables me to make a polar map (a great circle map) with any QTH being the center.

#1 I wrote a BASIC program in 1978 for the TRS-80 Model I that calculates direction and distance along a Great Circle between any two points on earth, using the spherical trigonometry I learned as a Navy fighter pilot. It has been published in several magazines, and has been updated to run in IBM BASIC, QuickBASIC, or QBASIC. I even have an EXE file to run from DOS. I do not have a Windows version.

Contact me at **818-346-7024** 9am-5pm pacific time, or at fblechman@juno.com to receive a copy of the program, variously called "DX Beam Aimer," "Long-Distance Navigator," or "Great Circle Program."

Fred Blechman
West Hills, CA

#2 *Byte Magazine*, June '79, has an article and BASIC programs for generating several varieties of maps, and it includes an azimuthal equidistant projection.

Unfortunately, I have lost the rest of the citation, and cannot tell you the author or the title. I found the article when looking for information about satellite tracking.

The article's code computes projections, but it does not include a map database (although it does give some pointers about where to obtain some).

Gerald Roylance
Mountain View, CA

TECH FORUM

ANSWER TO #7994 - JULY 1999

I need to set up a remote, wireless, video cam surveillance system. Where can I find instructions on doing so? Including the set up, specific parts that would be needed, and an explanation of the various terms and jargon i.e., "410 lines CCD, 0.3 lux, AGC, 4mm 78 FOV lens."

The jargon that you seek on CCD cameras is as follows; 410 lines refers to the scan lines of the camera.

The standard TV set in the US has 480 lines of scan from top to bottom, 60 times per second, which makes up the picture that you see.

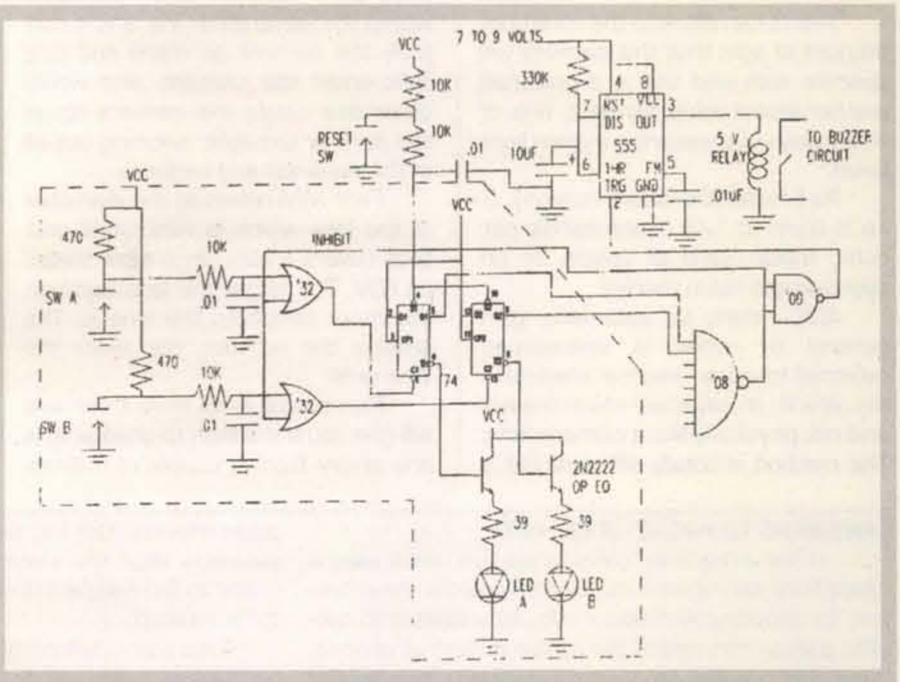
The way to think of this would be analogous to a page in a book that starts at the top right, and letter after letter is typed on that line until one line is full. Then the next line is started and filled until the entire page is full.

In the camera that you mention, there are 410 lines that make up a single page instead of the 480 that make up a standard TV picture.

What they are saying about the camera, is that its page is smaller and contains less information per page than on a standard TV set. Less information means lower quality in the picture, commonly referred to as resolution.

ANSWER TO #6993 - JUNE 1999

Recently, I committed to creating a buzzer and contestant identification light set-up for my high school debate club to use during competitions. I need help with the circuit design for this purpose.



This circuit operates as follows: Closing the reset switch sets the Q outputs of all the flip flops high, which causes the '08 output to go low. When a contestant closes a switch, the '32 output goes low making the '08 output high, which inhibits any other contestant's switch from having an effect.

The inverted Q output drives an LED through a NPN emitter follower.

If you want a brighter light, put a relay in place of the resistor and LED, and light an AC lamp.

The 555 timer energizes the relay for two seconds to operate the buzzer. The timer output could drive a small buzzer — like 273-054 — but the relay will drive a really loud one.

The logic VCC is five volts, but the 555 requires seven volts minimum to drive the five-volt relay. If the 555 supply voltage is too high, it may not trigger. I used a '00 gate to invert the trigger signal, but any inverting gate will do.

I have shown only two contestant's switch inputs to save space. Repeat the circuit in the dashed lines four times to fill the '08 inputs and complete the circuit.

The 10K resistor and .01uF capacitor at the '32 input is to prevent noise from causing false triggers and protects from static damage. The circuit will not work with TTL logic, but the type specified is CMOS.

PART	RADIOSHACK
470 ohms	271-1317
10K ohms	271-1335
33 ohms	271-1104
330K ohms	RSU-11345352
.01 uF	272-131
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LED	276-086
Switch	275-1566
5V relay	275-243
LM555	276-1723
74HCT00	276-2801
76HCT08	276-2805
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2N-NPN	276-2058

Russell Kincaid
Milford, NH

The .3 lux refers to the minimum amount of light that this camera will operate with and this is a universal mathematical value for light, one of many ways of measuring a given light value.

As I recall (the short version), .3 lux is equal to 1/3 of one candle per cubic meter/yard of space, or an approximate value thereof.

AGC refers to automatic gain control or what is sometimes referred to as an internal electronic iris which is adjusted electronically and not physically like a camera lens. The method is totally different but it works the same as an iris, and it controls the camera as more and less light enter the camera, and would otherwise cause the camera to go too dark or too light, washing out all of the contrast and features.

Four MM refers to the diameter of the lens which is very small and, thus covers a very large view, stated as FOV. The larger the lens number, the more telephoto the lens is. The smaller the number, the wider the view gets.

Purchasing a "C" mount camera will give you the option to change lens any where from a couple of millimeters to several thousands millimeters, which means that you can use the camera for astronomy, as well as house surveillance.

Seventy eight FOV refers to 78 degrees, field of view, which simply means that the camera can see from left to right and top to bottom, a view that is 78 degrees wide. This is generally referred to as a "wide angle lens."

As to the wireless transmission, the best way is to purchase a microwave transmitter which sends the signal down a 900 MHz or 2.4 GHz signal and gives you up to 1,000' of distance. They come in several versions that can handle one or more cameras at a time. They are reasonably priced and are available through advertiser's in *Nuts & Volts*.

The alternative is to build one, but working with microwave isn't recommended for the beginner.

Chris
Bieber, CA

ANSWERS TO #6996 - JUNE 1999

I need an inexpensive device to register the frequency of a PTO driven generator, so I can adjust the

Continued on page 92

ANSWERS TO #6992 - JUNE 1999

I have a "big dish" satellite system which uses a feed horn polarization motor that rotates the antenna for proper polarization. I do not understand how the pulses can rotate the motor in both directions, and also how the receiver determines just what the angle is. There doesn't seem to be any feedback from the motor shaft location to the receiver.

#1 The "polarity motor" is, in fact, a "servo motor" that many RC enthusiasts use to control their airplanes, cars, and what not ...

In general, a squarewave signal is applied with a specific duty cycle to place the motor between the extremes of ±90°.

The duty cycle range is approximately 10% to 90% (varies slightly per manufacturer).

Oddly, there is no feedback given to the source of the pulses. Not exactly a "servo loop," right?

The servo-loop is internal to the motor assembly. The source of the control signal (your receiver) simply applies pulses over enough time to assure the motor positions itself where it's supposed to be (despite where it is currently).

The duty cycle when filtered, represents a DC voltage that is compared to a feedback potentiometer. When the two signals are equal, the motor stops moving. The DC motor inside drives a gear assembly that translates so many turns of the motor to the number of degrees, the antenna "pickup" is rotated.

A common failure of a servo motor is "wear-out" where "backlash" from the potentiometer, the gears, even the housing contribute to the inability of the servo to settle into position. An oscillation results.

This can be tested by attaching the servo to the satellite receiver where it can be watched: Single-step the polarity adjustment slowly. Every third or fourth time, reverse direction for only one step, then resume until the end is reached. Repeat in the opposite direction. If, at any time, the servo appears to be "shaking its head NO!" the servo is bad.

Note that the feedback potentiometer is a very small Japanese or Korean model that is not easily found. I have no idea where you can obtain the gears or housings. If it is mechanically sloppy, just get a new one.

Don't confuse random movement with oscillation. Sometimes, strong RFI from a nearby radio station causes random "drift" from where the servo is supposed to be positioned. The reason it does this is because no pulse train is present.

Manufacturers of satellite receivers depended on the fact that the servo-motor had plenty of gears (with friction) that would tend to hold the polarity pick-up in position. Unfortunately, because the servo motors are made as cheaply as possible, they are not sheilded. Some manufacturers wised up.

To compensate, they supply either a constant stream of pulses or pulses every 10 to 20 seconds to keep the servo "refreshed." You can check this by replacing the servo with an LED and a 200- to 300-ohm resistor in series across the polarity signal and GND.

If you determine that your receiver is not sending pulses as described above, obtain a Chaparral "Polarotor" from the Electronic Goldmine surplus house in Arizona. This device doesn't depend on a CPU to update the polarity. It's a simple multivibrator circuit that operates at the correct frequency. (You'll have to adjust the polarity of every station manually, however.) Make sure you are getting the "servo controller," NOT the "ferrite controller!"

If the servo doesn't move at all, check your connections. Chances are that a fragment of wire trapped in the receiver's "polarity" connector is obstructing a good connection. Then, there's the possibility that the DC motor inside the unit is fried because of an electrical storm or spikes on the AC power source ... (The "Polarotor" would make a good test signal source without having to construct the whole thing!)

Before you try to test the device on a bench, you must really be sure you're matching the device to its environment. If your receiver doesn't send pulses regularly, the bench test is meaningless. And, all grommets should seal out moisture and spiders!

Matthew T. Allen
Santa Clara, CA

#2 The motor sounds like a typical servo motor such as used in RC planes. The motor angle is controlled by pulse width modulation setting the angle.

The motor has its own internal feedback loop to keep it in position. So, the main receiver only needs to send the correct pulse width and be assured of its angle without a feedback loop to it.

To build a test rig, I don't remember where I saw the schematic, but you can build a pulse width generator by using a 555 timer and some parts. Look under RC servos for info, other circuits should exist.

Tony Gonzalez
Gardena, CA

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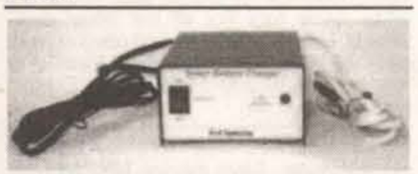

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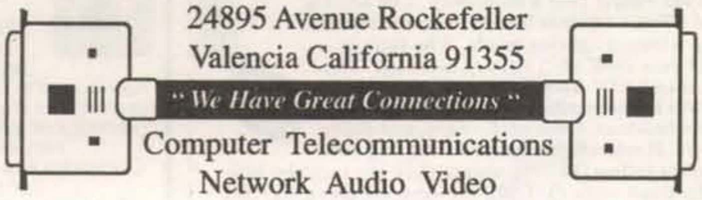

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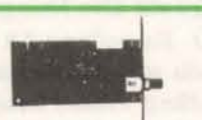

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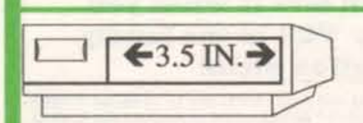

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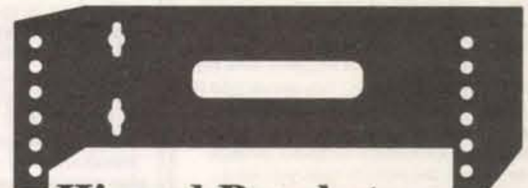

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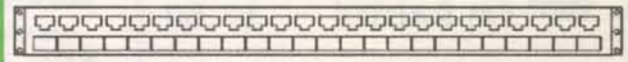

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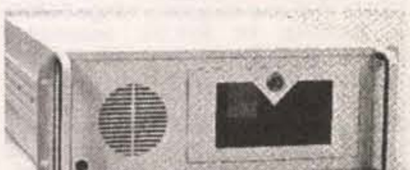

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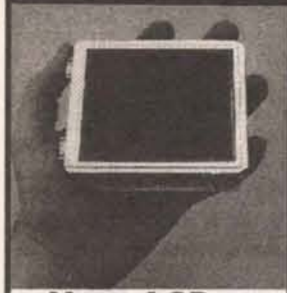

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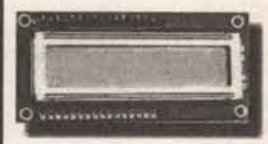

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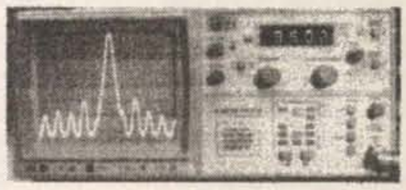

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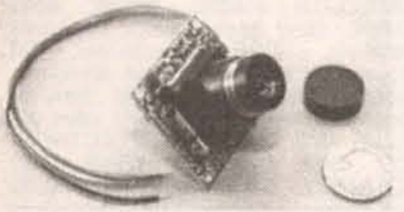

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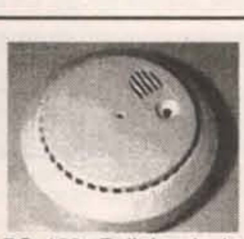

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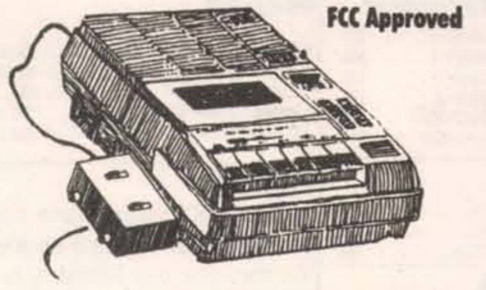

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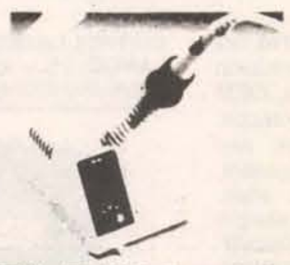

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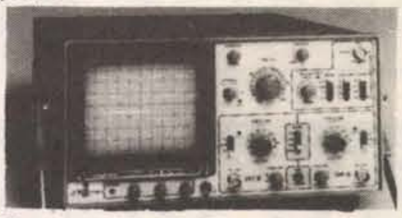

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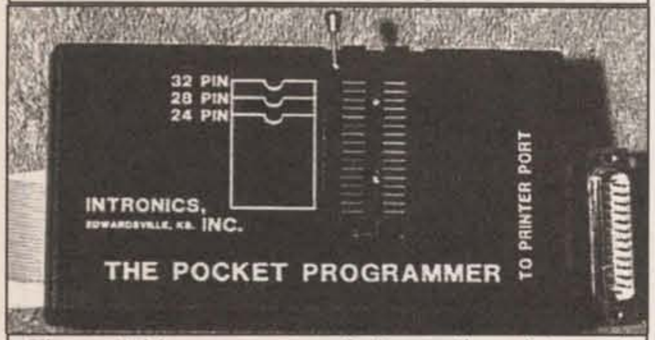

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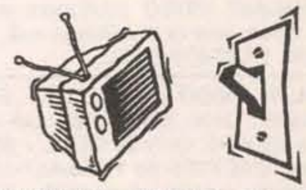

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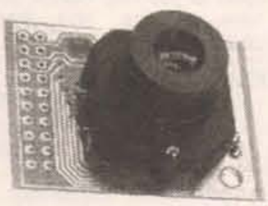

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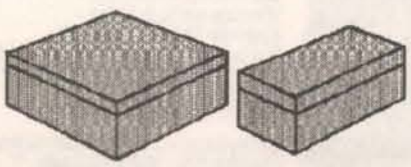

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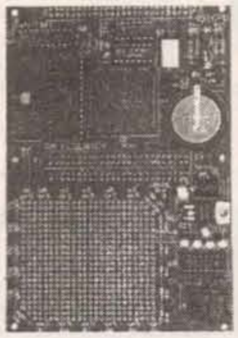

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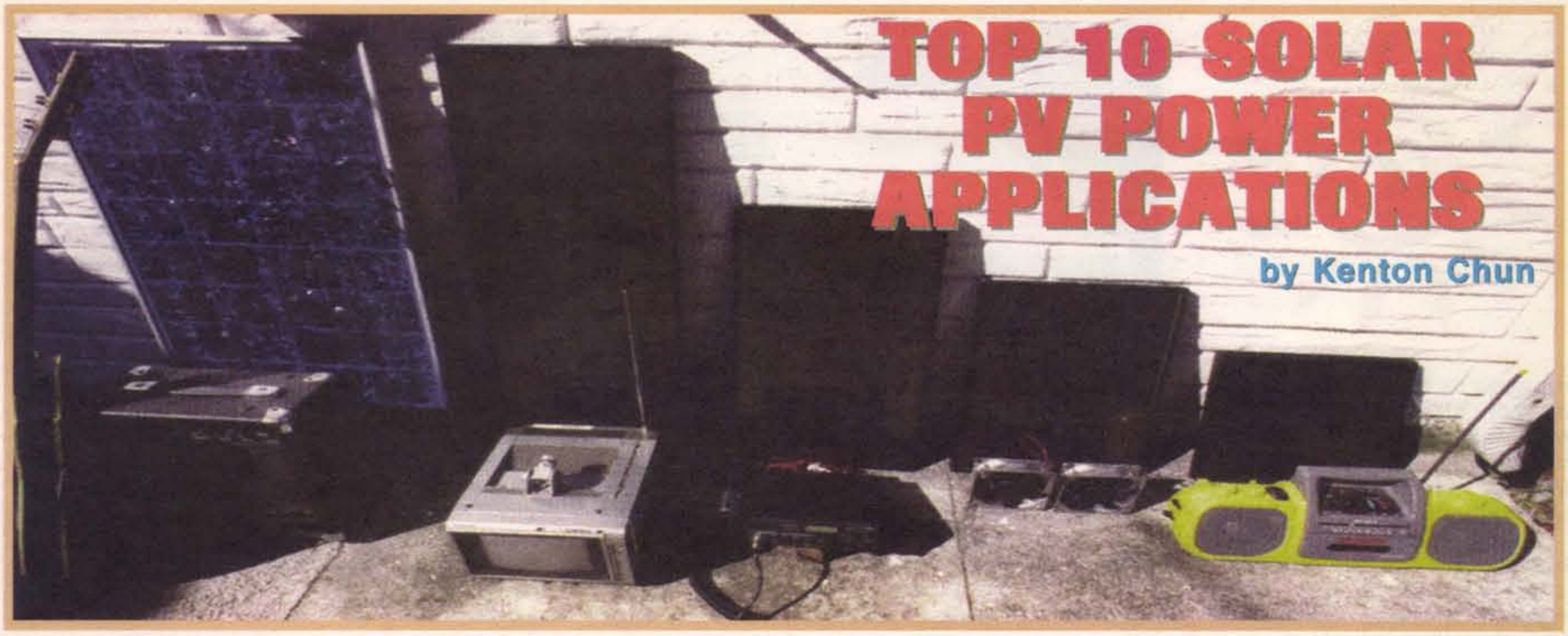
Continued on page 56



TOP 10 SOLAR PV POWER APPLICATIONS

by Kenton Chun

When choosing an application for solar power, it is important to consider the practical end, as well as the fun of it.

Solar-powered projects can be expensive, so the cost must be justified against the benefits. This month, we'll look at 10 applications of solar power that will show positive cost benefits to the hardware hacker for implementing them. This should keep even the bean counters happy!

Solar panels, or PV (Photo Voltaic devices), generally have a relatively high initial cost, and a long pay back period. However, for technological devices, they also have a surprisingly long depreciation period.

Well-maintained solar panels can provide constant power for well over a decade. Newer solar panels are guaranteed for 20 years! Compared to a personal computer – which is usually obsolete inside of three years or less – solar panels can be a good long-term investment – if you have an application for them.

Understanding how solar panels work is important if you are going to try to recover their initial cost. Obviously, they do not work in the absence of direct sunlight. Their efficiency is hampered by clouds, shadows, and other sun obstructions.

Sizing the panels to the specific applications you are employing them in is vital in order to minimize cost. And you may need to redesign the application to some extent, in order to accommodate the solar panel's operational requirements and limitations. In some areas of the country, it is possible to run an entire household off of a large PV array (Figure 1).

1. REPLACING ALKALINE BATTERIES

When you realize that the average household contains devices employing over 200 batteries, it becomes an interesting struggle to keep all of them alive. Alkaline batteries are by far the world's most expensive energy source, per watt. The price for powering devices with alkaline batteries is somewhere between $250.00 to $500.00 per kilowatt hour, depending on the type of cells you are using. Remember that the next time you are conducting a fruitless search for something with a flashlight. In terms of payback and practical application, the top three candidates for solar power replacement of alkaline batteries are:

1. Radios, boom boxes, and CD players.
2. Small portable TVs.
3. Handheld LCD display games.

Most of these types of devices may be driven directly off a solar panel at a picnic, the beach, or other family outing, with virtually no noticeable performance issues. After all, if it starts to rain, who is going to hang around on the beach listening to the radio? An average boom box may need from 6 to 12 volts at half an amp to be run at full output, considerably less at normal listening volumes. A 1' x 1' solar panel rated at 3 to 4 watts is ideal for this sort of application.

It has an open circuit voltage of about 23 volts and will supply 2 to 300 milliamps of current at 14.5 volts. Most solar panels are power rated at 14.5 volts which is charging voltage for lead-acid batteries. Sturdy 3.5-watt panels cost about $40.00. A simple voltage regulator circuit will limit the voltage of the panel should your radio supply require less than 12 volts. A surprising number of devices appear to be very tolerant of fluctuating supply voltages as long as they are above nominal supply voltage. Small devices, such as handheld games, may be run off a few individual solar cells wired in series.

Assuming you take your radio to the beach, fishing, or picnics often, and if it uses eight alkaline "C" cells, you will hit payback inside of four battery changes with a solar panel. This could be less than two weeks of continuous daily operation!

2. CHARGING UPS BATTERIES

In the Dec. '97 issue of *Nuts & Volts*, we showed you how to replace the dead battery in a UPS (Uninterruptible Power Supply) with a lead-acid deep cycle battery of higher capacity than the original one. This allows the UPS to be run for longer periods before requiring load shutdown. Because of the intermittent nature of UPS operation, it is an ideal candidate for solar panel charging.

In South Florida, we literally have hundreds of short duration power "hits" lasting under 500 milliseconds per year. These are very annoying because they are just long enough to reset VCR clocks, and crash computers. With UPSs on every mission-critical electronic device in the house, a solar panel makes a good free charg-

To give you some ideas, here are a few common devices and the panels they would require in order to operate. Obviously, some of these will overlap if you are willing to accept de-rated performance:

PANEL WATTAGE	Approximate Panel Dimension	DEVICES
3 – 4	12" x 12"	"Boom Box" @ 30-50% Volume Handheld GPS Handheld Cellphone Low Power Walkie Talkie High Volume Muffin Fan Personal CD or "Walkman"
4 - 6	12" x 18"	Pair of High Volume Muffin Fans CB Radio UPS Battery Charging Video Camcorder
6 – 8	12" x 24"	Ham Radio (With Battery for TX) Car or Boat Battery Charging Aquarium Pump/Filter
11 – 13	12" x 36"	6" Portable Color TV Laptop Computer 110 VAC Inverter Quick Charge Nicad Power Tool
50 – 60	19" x 36"	Portable Gorilla Guitar Amplifier Small Pool Pump 19" Color TV Coleman Electric Cooler

Figure 1 — Solar House

ing supply for the batteries. The average duty cycle of the battery in standby mode is only a few minutes a year, so a relatively small 5-10 watt panel is ideal for maintaining our lead-acid UPS batteries at top charge.

If you decide to charge lead-acid batteries on solar panels, it would be a wise precaution to use a charge regulator. A charge regulator will keep the voltage around the optimum 14.5 volts required for charging lead-acid batteries, and it will taper the charge off when the batteries approach full charge. This will prevent boiling off the electrolyte in the batteries which decreases their life. Batteries maintained in this fashion will always be ready for full standby operation for many years.

3. CHARGING BOAT/ CAR BATTERIES

If you are like me, you manage to find the time to use your boat or jet ski maybe three or four times a year. This is a problem for the starting batteries because after a year of neglect, they often need to be replaced at a cost of $50.00 or more. A small four-watt solar panel and charge regulator will keep these batteries in top standby condition without requiring a 50 foot extension cord and a dedicated automatic charger on the battery. These two items at Sears would set you back about $75.00. The payback on the solar panel here is inside of one year.

4. NIGHT LIGHTING

Night lighting is an interesting solar application because here you are nearing 50% duty cycle. You have all day to collect energy from the sun and you want to burn it all night. The key to this sort of operation is efficiency. If you are setting up night lighting in the home, you should use LEDs whenever possible in higher visible frequencies like green or yellow.

For outdoor yard lighting, use a nicad battery powering very low voltage lighting. A 24-volt nicad will run six or eight sidewalk lights rated at three volts and connected in series. A typical three-volt incandescent light will draw 200 milliamps at three volts, so a string of six of these will consume about four watts. A four-watt solar panel will therefore yield about as many hours of nighttime operation as daytime charging. You can charge all day and burn all night.

The payback is very slow when you compare this to running your night lighting off of the power utility, but it may actually be a good alternative to nothing at all in remote places like vacation cabins, or RVs when the local power utility is not an option.

5. ATTIC VENTILATION

Attics get the hottest during the noon hour, so this is an ideal solar application. A large 12-volt DC muffin fan drawing about 400 milliamps can move 100 CFM of air. Four of these fans can exchange the air in even a large attic in under one hour. Significant secondary benefits from ventilating the attic can be lower air conditioning costs and decreased attic condensation damage.

Even a single fan moving only 100 CFM will exchange the air in a 50' x 30' attic in about 75 minutes. A five-watt panel is sufficient to power this project. An additional payback on this project is convenience — it operates automatically and needs no attention. The fan runs directly off the solar panel so there is no battery maintenance.

6. AQUARIUMS AND FISH PONDS

Daylight-only operation is fine for aquariums and fish ponds. Fish sleep just like people during the nighttime hours, and having a constant flow and rush of air can be stressful to them. Although it is difficult to find small DC air pumps, it could be worth the trouble if you are trying to keep fish alive in a remote area (like a vacation home) where constant power is not always available.

7. HAM RADIOS

Radio hams have long known of the advantages of solar power. Most modern portable radios will run nicely in receive mode on less than 500 milliamps of current at 12 volts. A six- or seven-watt panel will keep the radio running all day without draining the battery, and will help recover from the larger current demands of transmitting. Most DX expeditions to remote places like Antarctica, Easter Island, and the tops of mountains are accomplished with the aid of solar power.

In the event of a natural disaster, ham operators depend on solar backup to provide power when the utility goes down. Solar-powered radios can save lives, speed aid, and provide tremendous flexibility of portable operation. Even for non-hams, within a week of a natural disaster, most cell phones would have dead batteries — staying on the air is assured with a solar standby charging arrangement. And solar power has the added attraction of being environmentally friendly and decidedly low-tech, as opposed to gas-powered generators or other alternative energy sources.

It is impossible to gauge the payback value of helping to save lives.

8. CHARGING ELECTRIC LAWN TOOLS

If you are a dedicated lawn warrior, you are probably out every weekend all summer working on the lawn. You may have a battery-

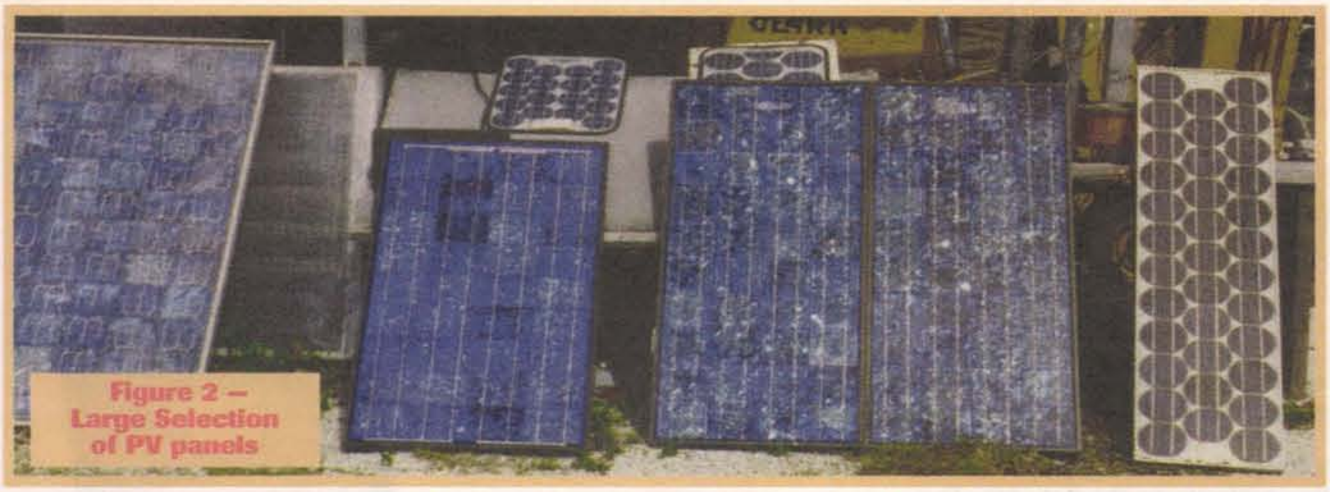


Figure 2 — Large Selection of PV panels

operated device like a leaf blower or edge trimmer, or even an electric lawn mower. In this scenario, the duty cycle is a couple hours of operation a week or one percent, so even low powered solar will work just fine. Slow charging nicads over the course of a week at (I/10) is easily accomplished with a 10-15 watt panel for even a large electric lawnmower. You could charge several yard tools at once with a solar panel at this rating. A 14-watt solar panel will run about $100.00. The payback here is in convenience. If you keep your lawn tools in an outdoor shed or remote corner of the yard, the solar charging system will save on extension cords or running new utility service.

9. POOL PUMPS AND HEATERS

A pool is one of those awful things that costs a fortune to install, operate, and maintain, but which adds very little to the resale value of a home. Naturally, it would be nice to decrease the costs and maintenance of keeping one. A solar application works nicely for a swimming pool. Running a DC circulation pump directly off a solar panel will move water and get the job done. Sure it doesn't work when it's cloudy or raining, but who cares?

In this case, a 50-watt solar panel can move 1000 GPH of water through a pool heating and filtration system. Take 200 feet of black poly pipe and throw it in a sunny part of the yard. Run it into the intake of the filter system and connect your DC pump to the return. A 20' x 30' x 6' pool containing about 30,000 gallons will have a complete exchange of water through this system every three days or so. So what if it is only running during the daylight hours?

Conventional gas or electric pool heaters are very expensive to install and operate. Depending on how much you use your pool and how warm you want to keep it, a solar installation can easily pay back its costs in only a few summers or less. A 50-watt panel will cost from $250.00 to $300.00.

10. WATERFALLS AND FOUNTAINS

Most waterfall and fountain pump systems run on timers because they are only intended to run during the day when people can see them. This is a perfect solar application. When the sun goes down, the fountain goes off. A small submersible DC pump makes a great water fountain or small waterfall water supply. It is especially pleasant from an environmental point of view because it "responds" to the day. Shortly after the sun rises, the fountain starts up and gets higher until the sun is directly overhead. Then as the day wanes, the fountain gets lower and finally stops as the sun drops below the horizon. How much more environmentally friendly and "in tune" with nature can a system get?

AND EVERYTHING ELSE

All of the projects mentioned up until now have been powered with DC (direct current), and have relatively short duty cycles. There are actually quite a few AC (alternating current) devices which also have relatively short duty cycles, and which may be powered by solar panels. The difference is that they may have rather high starting power consumption requirements and require the use of a power inverter.

With the advent of efficient metal oxide field effect power transistors (MOSFETs) and excellent transformer design, power inverters have become extremely efficient. It is possible to purchase power inverters which can convert DC to AC with close to 90% efficiency. They also have excellent short-term overload capacity for starting inductive loads. In standby mode, a well-designed inverter can sit forever at no load drawing only a few milliamps of current!

With small power inverters becoming cheap and plentiful, it is now possible to run AC projects directly off solar panel power. When the solar panel begins to produce enough power to run the inverter, it begins to invert, and off you go — a conventional AC aquarium pump can easily be operated in this manner.

Larger loads will require a battery for reliable operation. For remote locations where the utility grid is not accessible, it is even possible to run a small refrigerator off of a battery-powered inverter that is being charged with a modest-size solar panel array. Two or three 80-watt panels can easily keep a small AC-powered refrigerator running (provided the door isn't open all of the time, and the compressor is cycling off periodically). PV solar panels are available in practically any power rating you may need (Figure 2).

Whether you want Mozart playing in the background or a cold one in the fridge, you can accomplish it with a solar array. With some design and consideration, you can even make it pay for itself! Remember to have fun whatever you do. **NV**

Solar Sources:

Tropico Solar
Newfound Harbor Rd.
Big Pine Key, FL 33043
(305) 872-3976
E-Mail: enewbery@inetw.net

BP Solar
http://www.bp.com

Photocomm, Inc.
http://www.photocomm.com

HIGH "TEC" REFRIGERATOR

by Kenton Chun

We have all seen them in the sports department of our local superstores – electric coolers.

It's the sort of thing that makes a hardware hacker's palms begin to sweat. The average price on one of these babies is $80.00. But before you pull out your credit card, take a look at this month's project.

For a quarter of the price, you can build one yourself. We even decided to go a step farther and make ours solar-powered.

The heart of the electric cooler is a Thermoelectric Cooling heat pump (TEC). Also known as a Peltier device (named after its inventor), the TEC consists of semiconductor junctions that are assembled between and bonded to two ceramic plates.

When a DC current is passed through it, heat is "pumped" from the cold side to the hot side. The cold or hot side is determined by the direction of current flow. Reversing the current flow will reverse the hot and cold sides.

In its basic form, a TEC system consists of four parts: a hot side exchanger, a cold side exchanger, the TEC device, and a power source. The hot and cold exchangers are only common aluminum heatsinks with attached fans to increase their efficiency.

All a thermoelectric heat pump requires to function is clean DC power. Batteries, automotive and marine DC systems, AC/DC converters, linear and switched DC power supplies are all appropriate power sources for TECs. Most applications are optimized at 75% of maximum ratings for the TEC device.

Figure 1 — Too small of a heatsink will freeze.

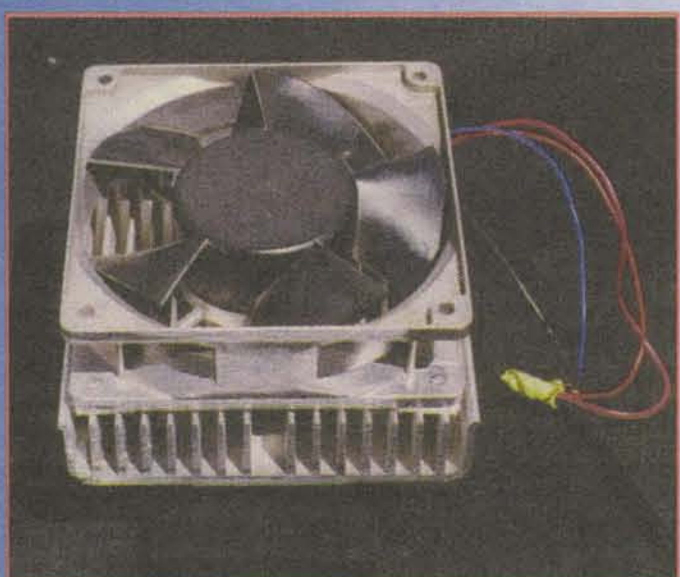


Figure 2 — Hot side muffin fan.

For a quarter of the price, you can build an electric cooler yourself. We even decided to go a step farther and make ours solar-powered.

The Peltier Effect was discovered in 1834 by Jean Charles Athanase Peltier. When current passes through the junction of two different types of conductors, it results in a temperature change. However, the practical application of this concept required the development of semiconductors that are good conductors of electricity but poor conductors of heat – the perfect balance for TEC performance.

Today, bismuth telluride is primarily used as the semiconductor material, heavily doped to create either an excess (N-type) or a deficiency (P-type) of electrons. Modern TECs are capable of achieving 50-degree temperature differentials in a single stage.

When cascaded in multiple stages, TECs can achieve extremely low (near cryogenic) temperatures. The electric coolers you can buy in the sporting goods department will stabilize at just about 40 degrees in an 80-degree ambient environment.

We decided to build a cooler that would be compact and convenient to use in a car. We chose a Coleman eight-quart cooler as the basis for our project. You can use any type or size cooler for your project, but you should run some tests first to determine the efficiency of the insulation in the cooler.

The simplest test is to fill the cooler with ice and see how long it takes for the ice to melt at ambient room temperature. Our little Coleman was not bad in that, after 24 hours, it still contained about 80% of the ice. The greatest losses were through the top and bottom of the cooler where the insulation was the thinnest.

We purchased a TEC device from an advertiser in *Nuts & Volts.* It came complete with a hot side heatsink and is rated at 4.5 amps at 12 volts. We purchased a somewhat smaller cold side heatsink at a local hamfest. We chose our cold side heatsink for its low profile, allowing us the greatest amount of room inside the cooler after installation.

Because of the lower cold side efficiency of the TECs, it is not necessary to have the same area of heatsink on the cold side as on the hot side. Our cold side sink was only about 40% of the hot side area.

The choice of the cold side heatsink has a significant effect on the final performance of the cooler. Because of variations between coolers and TECs, it may be necessary to experiment in order to determine the optimum heatsink for your cooler. One good rule of thumb to remember is to size your cold-side heatsink so that it stays a few degrees above freezing without a fan. Once the sink hits freezing, it will develop a frost coating which will decrease cooling efficiency (Figure 1). Either add a cold-side fan or increase the heatsink size to remedy this problem. We matched our hot side heatsink with a four-inch 12-volt muffin fan (Figure 2).

GETTING STARTED

Begin by preparing the cold side heatsink. Drill holes to match the studs on the cold side of the TEC. Make sure to drill the holes in a location that falls between a pair of cooling fins, even if it is not in the exact center of your heatsink. If the fins are very close together, it may also be necessary to mill or carefully drill out an area large enough to accommodate the mounting nuts. Remember you must also tighten the nuts with a pair of needle-nose pliers or a nut driver when dimensioning this space. Check and make sure that your heatsinks and the TEC surfaces mate without rocking. Remove any metal burrs

which may be preventing them from doing so (Figure 3).

Next, measure the cold side dimensions of the TEC. Transfer this measurement to the lid of the cooler, making sure the larger hot side heatsinks will not interfere with anything, and carefully cut a hole to fit the device with a jigsaw.

In general, it is slightly better to mount the TEC so the heatsink fins are vertical so that, in the event of fan failure, there will still be some natural air convection across all of the fins. We chose to mount the TEC in the top of the cooler to allow the greatest room for storage inside. Mounting the TEC in the lid gives you the added option of simply changing lids to turn the cooler back into a non-electronic type.

The device should fit snugly in the hole allowing the power cables to pass to the outside of the cooler without strain. If you are using a cold side fan, it is important that the power leads pass through the cooler lid leaving enough space to mount the cold side heatsink flush with the surface of the TEC.

Attach the muffin fan to the hot side heatsink, using either a dab of silicone sealer on each corner, with some small angle brackets, or even with velcro. The fan should be blowing air into the center of the heatsink and the air should exit through the open ends. You can reverse the flow if you wish, but we found it runs quieter this way.

Wire the TEC and fan in parallel using a good quality stranded 18 gauge wire. Most TECs have color-coded pigtails; the positive lead is the red one when the device is in cooling mode. You may wish to connect your TEC to a 12-volt power supply or battery to verify that this is the case with your device.

If you wish, you can terminate the power leads in either a pair of battery clamps or in a polarized power socket. Make sure it is rated for at least 5 amps at 12 volts DC.

When you are done, you should have something that looks similar to Figure 4. Using a good quality silicone sealant, seal the outside edges of the TEC around the hole. Clamp the device to the outside of the cooler overnight until the sealant cures.

Carefully fill any gaps between the edges of the holes and the cold side of the TEC making sure not to get any sealant on the surface of the device. If some gets on the TEC, wipe it off immediately.

Your cold side TEC surface should be flush or above the inside of the cooler lid. If you have additional space between the TEC and the lid, you can use a piece of styrofoam as a spacer for a snug fit.

Next, bolt on the cold side heatsink using a tiny amount of heatsink grease between the two. You only need enough to contact both surfaces. Tighten the mounting nuts down but do not strip the bolts. Use a properly-sized pair of split lock washers under the nuts. Aluminum has a fairly high thermal expansion coefficient, so it may be necessary to recheck the nuts after the cooler has been on for a few minutes.

FINAL CHECK AND TESTING

Connect your TEC cooler to a 12-volt power supply capable of supplying 5 amps. Both fans should begin to turn, and the cold

Figure 3 — Mounting the cold side heatsink.

side heatsink should immediately turn cool. If it instead begins to heat up, disconnect the power and reverse the TEC leads. The hot side heatsink will not get hot immediately because of the larger thermal area and fan cooling assistance.

If the device appears to be getting cold, wait for 5 or 10 minutes, and then recheck the tightness of the mounting nuts on the cold side heatsink. Once you have tightened it cold, you should not need to retighten it again. You can check the performance of your cooler by placing a digital thermometer sensor inside the cooler and checking it at regular intervals.

OPERATIONAL NOTES

It is possible to reverse the direction of the heat pump by simply reversing the power leads to the cooler and thereby turn it into a heater. However, you may have to modify the fan power circuit because reversing the power polarity on many brushless DC fans will cause them to stop running. They will not reverse.

TEC devices will actually consume less power after the temperature has dropped inside the cooler. Do not be tempted to exceed the operating voltage in hopes of gaining efficiency. TECs are current devices and increasing the voltage may damage them or actually decrease your cooling efficiency. TECs will operate more quickly at rated current, but will happily function with less. For this reason, they are ideal for use with solar power.

SOLAR POWERED FRIDGE

We decided to take it a step farther and try a solar power experiment. Because of the good thermal insulation properties of our little cooler, we decided to try to run our TEC refrigerator off of a PV (Passive Voltaic) solar panel. From a practical standpoint, there are only a few ways one can store solar power for later use. The conventional way is to charge a battery and then discharge it later through a load after the sun has set. We decided to try and use our TEC cooler to store "cold."

With the TEC running full blast, our cooler consumes just under 50 watts. We set up the cooler to run directly off a Tropico 53-watt panel regulated with a 5-amp 12-volt voltage regulator (Figure 5). With about seven useful hours of solar energy available in February, and a starting ambient temperature of 78.8 degrees F, we were able to bring a six pack of diet cola down to a cool 42 degrees over the seven hours.

The TEC continued to operate even when a cloud passed in front of the PV panel, and the drive voltage dropped to only six volts. Our drinks stayed pleasantly cool all night. We were pleased and amazed to see that we could keep our drinks cold by using sun power alone!

Although we were unable to drop the temperature sufficiently to make ice in the cooler, we found that, by keeping the temperature low, we could easily preserve ice stored in the cooler for several days. This is good enough for the average road trip or picnic.

•

Remember to have fun whatever you do! **NV**

Figure 4 — Mounting the TEC assembly in the cooler lid.

PARTS LIST:

- Coleman Six-Pack Cooler or similar *(see text)*
- 12V Thermoelectric Cooling Device (TEC)
- 12V Brushless Four-inch Muffin Fan
- 1 Cold Side Heatsink *(see text)*
- Tube Silicone Caulk
- Tropico 53W Solar Panel
- Assorted Hardware and 18GA stranded hookup wire

The author wishes to thank **Tropico Solar** for the use of the PV panel employed in this project. Tropico Solar can be reached at (305) 872-3976 and you can E-Mail them at enewbery@inetw.net.

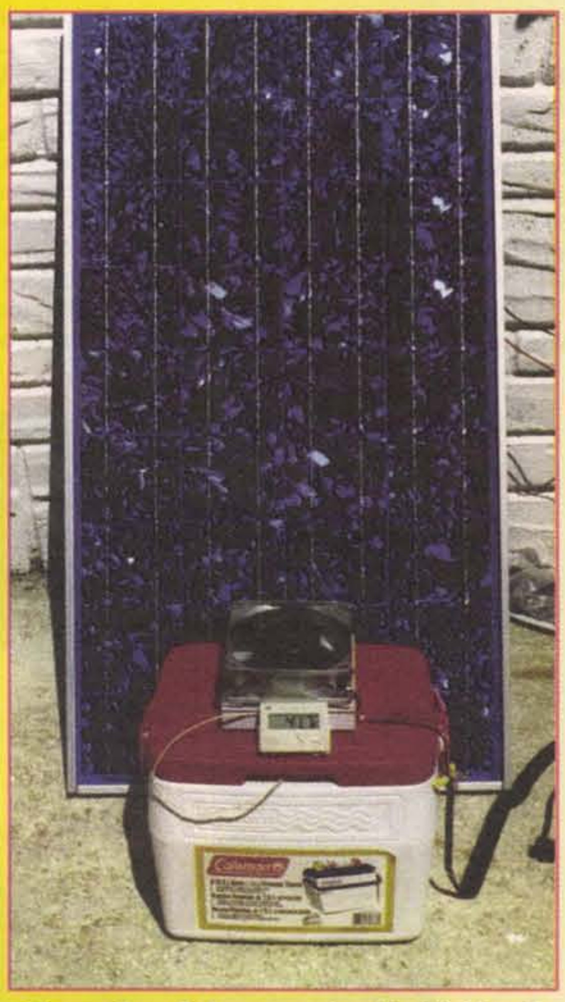
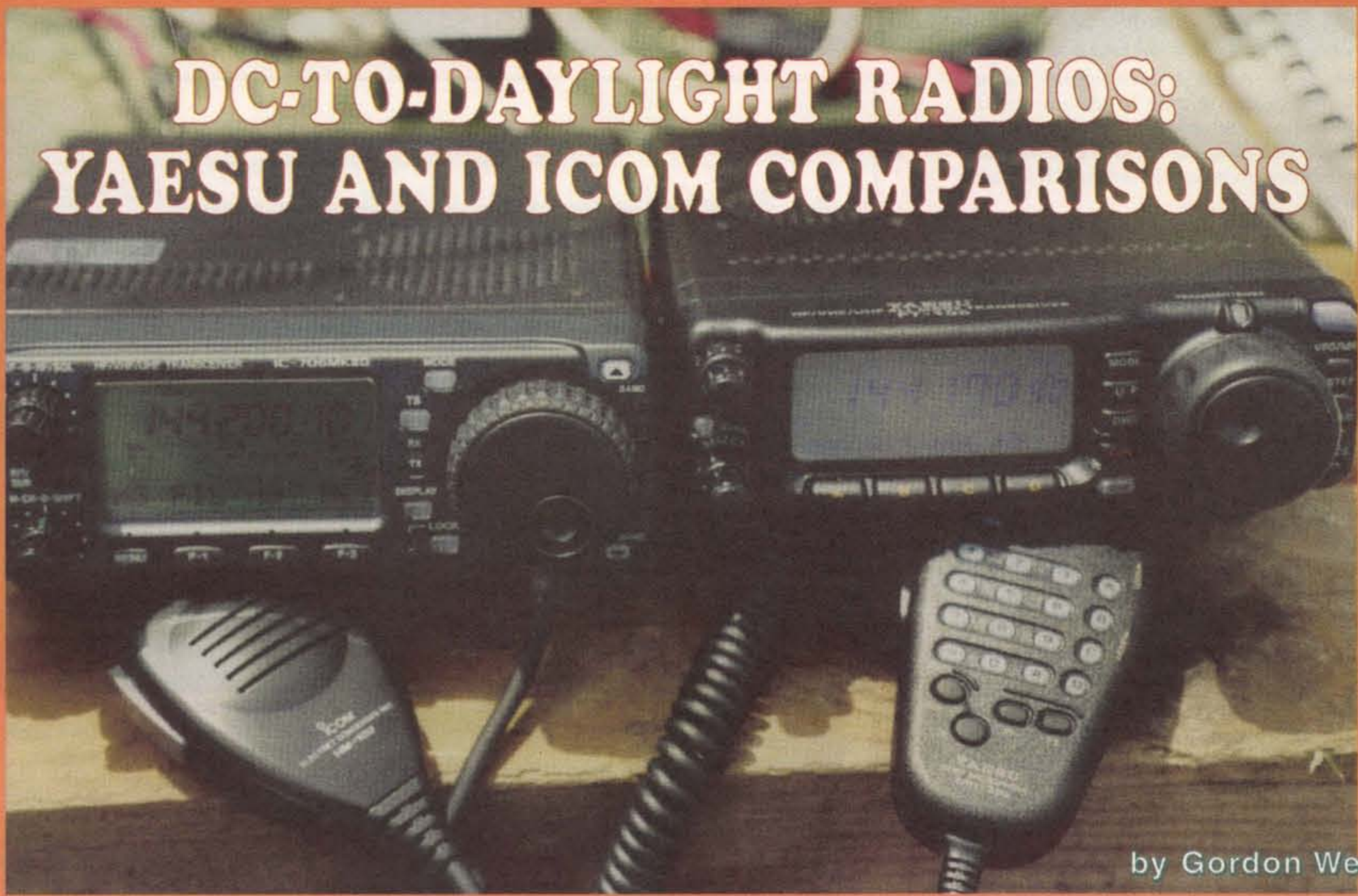


Figure 5 — Solar powering the "fridge."



DC-TO-DAYLIGHT RADIOS: YAESU AND ICOM COMPARISONS

by Gordon West

... Two brand new HF/VHF/UHF ham transceivers from Yaesu and ICOM undergo side-by-side comparisons, along with some torture tests, too, in a review of the latest technology that goes from 500 kHz to 500 MHz, plus higher on receive ...

Amateur radio equipment manufacturers Yaesu USA and ICOM America have simultaneously introduced a compact amateur radio transceiver that offers 100 watts output on ham bands from 160 meters to six meters, plus 50 watts output and all multi-mode capabilities on two meters, PLUS 20 watts output, full multi-mode capabilities, on the 70 centimeter bands.

ICOM calls their equipment the IC-706 MK II G, and Yaesu calls their DC-to-light amateur transceiver the FT-100. Both companies introduced this exceptional equipment within one week of each other last April, and both units have been seen selling in the $1,375.00 price range.

What makes both of these transceivers unique to the amateur industry is their ability to combine 500 kHz to 500 MHz capabilities all in one nice, neat package. Kenwood Corporation offers the Kenwood TS-50, and Alinco offers the DX-70, and these similarly-sized transceivers are terrific high-frequency performers, but neither the Kenwood nor the Alinco combine two-meter capabilities and the incredible Yaesu and ICOM accomplishments of 440 MHz multi-mode transceive.

ICOM America was the pioneer in adding VHF to a small packaged HF transceiver back in 1995 with their IC-706. Two years later, they came out with the IC-706 MK II where they added more power on the two-meter band and enhanced wide-band receiving capabilities. Then Yaesu and ICOM simultaneously brought out their HF plus six meters, plus two meters, plus 440 MHz multi-mode transceivers with plenty of similarities between themselves, and comparable street prices that might have hams scratching their heads wondering WHICH ONE IS BEST?

Reading over the specification sheets may be a good start to figure out which one is BEST, but there is nothing better than a side-by-side, in-the-field comparison between the two, and that is exactly what I did during the month of April.

- Yaesu FT-100, serial No. 9E031474
- ICOM IC-706 MK II G, serial No. 01264

COMPARISON PROCEDURES

Both units were obtained from the manufacturer, but neither had been opened up ahead of time for any extra "tweaking" and quality assurance. The comparison was conducted at the home station into a contest-capable, high-frequency Yagi. The equipment was also compared side-by-side in the communications van in the field near a major mountain-top relay site. This location is known for its intermod generating capabilities. The equipment was also compared side-by-side in an off-the-road dune buggy in order to maximize engine static.

Side-by-side comparisons included simultaneous receive on a common antenna with appropriate isolation networks in order to minimize one radio loading down the receive capabilities of another. Simultaneous receive on a test antenna at a test location gave us fast and accurate comparisons of the receiver capabilities. We would also switch each set into the antenna, by itself, to further verify independent receiver performance.

SIZE AND WEIGHT

ICOM IC-706 G weighs in at six pounds, including mike, but less the mounting bracket.

Yaesu 100 weighs in at about five pounds, including mike, but less the mounting bracket.

ICOM is about 10 inches in length, and Yaesu is about 9-1/2 inches in length. Both units are around two inches in height, with ICOM a fraction more chubby. Both units are about 6-1/2 inches wide.

Both units feature detachable head capabilities. But it will cost you another $75.00 for the necessary head-separation kits.

The ICOM separates with a single multi-conductor cable that conveys all separated front panel information to the body. The ICOM mike plugs into the separated head, and the separated head can provide switchable headphone or speaker capabilities out the front mini phone

jack. The Yaesu requires three control cables: one for running the remote head, one for the external speaker, and one for the microphone. This set-up could allow the speaker and the mike to emanate from an area not necessarily directly on the head.

ICOM supplies a lightweight mike with up-and-down buttons on the top, plus a lock switch. A microphone with keypads is available as an option. On the Yaesu, they supply an elaborate mike with back-lit keys, up-and-down buttons, lock, and several additional programmable buttons. On the microphone length test, both were relatively long, but the Yaesu mike went even a foot further.

COOLING

Both sets ran relatively cool on both receive and transmit. ICOM uses an internal big fan to blow out the hot air, and Yaesu uses two smaller fans mounted on the rear to provide plenty of fresh cool air to all of the PA transistors.

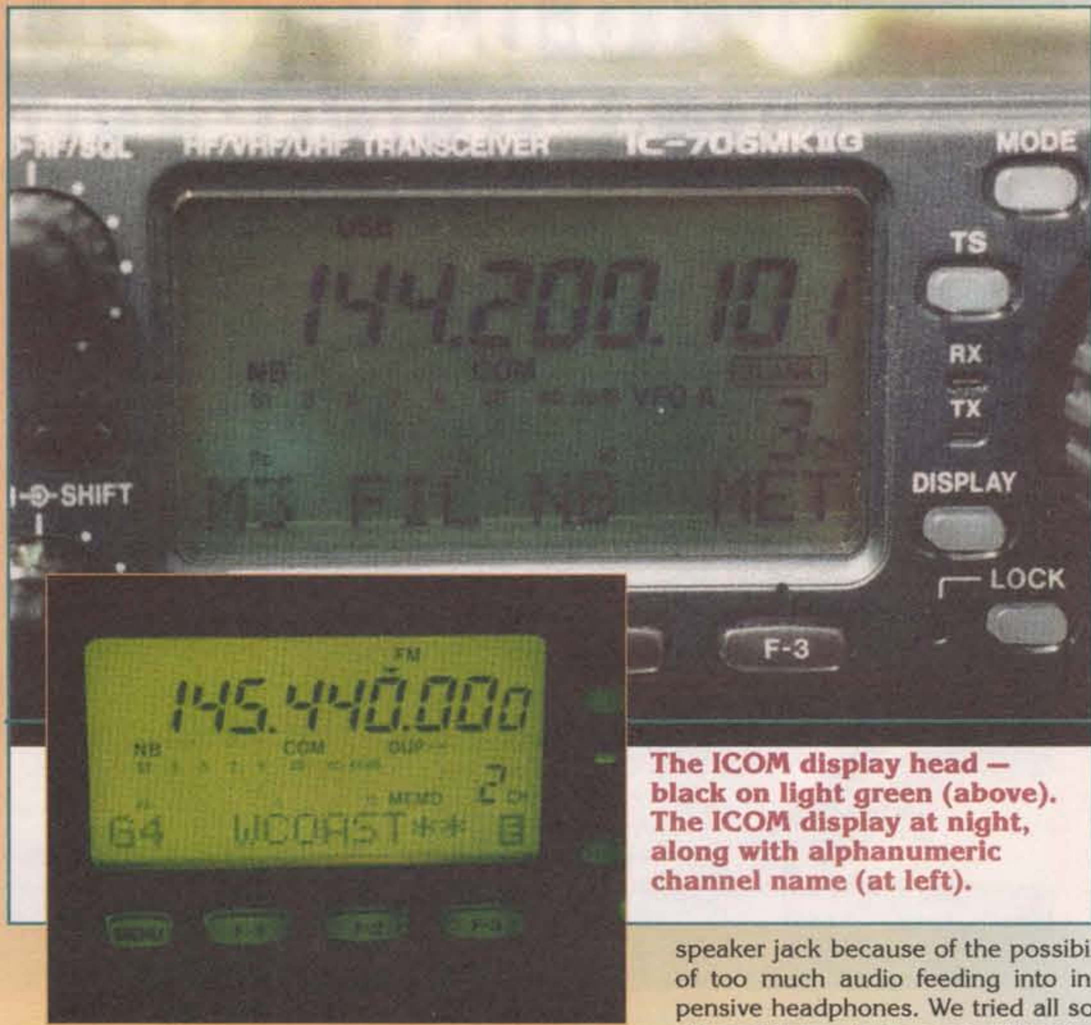
POWER CORDS

ICOM supplies the customary six-pin power receptacle, along with twin round fuses found at the opposite end of the long cable. The fuse holders may be opened up to allow the cable to easily poke in through an extremely small fire wall rubber boot.

Yaesu offers a pigtail with heavy-duty blade connections to their long power cord. The power cord also features automotive blade fuses at the far end. If your vehicle has a large fire wall rubber boot, no problem — but if the hole in the fire wall is rather small, you may need to cut the red and black wires in order to facilitate getting through a very small fire wall hole.

INTERNAL SPEAKERS

The ICOM internal speaker is larger with a more full sound. The Yaesu internal speaker is smaller, with a more crisp sound. Both units offer an external speaker jack on the back of the equipment for plugging in an external speaker. When hooked up to an external speaker, both the units sounded almost identical for audio fidelity and plenty of robust audio output power. Yaesu cautions the use of headphones off of the rear speaker jack because of the possibility of too much audio feeding into inexpensive headphones. We tried all sorts of headphones in the back of the Yaesu equipment, and all sounded just right at one-third volume setting. This included the Heil headset, as well as all sorts of contest headphones. But keep in mind that the ICOM also offered a second headphone/speaker jack on the left-hand corner of their front panel.



The ICOM display head — black on light green (above). The ICOM display at night, along with alphanumeric channel name (at left).

THE LCD DISPLAYS

The Yaesu display measures a little over an inch high and about 2-1/2 inches wide. The ICOM display is the same width, but noticeably a half-inch taller. The ICOM display is an LCD light green background with black bold characters. Screen visibility at all lighting conditions and at all front panel angles was judged "the best" by several ham operators assisting with the comparison.

The Yaesu FT-100 display is an LCD light blue background with royal blue LCD characters. When back-lit at night, it was quite pleasing to drive by — but during the day, the definition of the blue-on-blue display was not as crisp as on the ICOM green and black display. The Yaesu head is best mounted up high on the dash where you can look square on it, as opposed to losing some definition when trying to view it at an angle, or looking down on it when not pointed directly at you.

OPERATING KNOBS AND CONTROLS

We found a lot of similarities

The Yaesu remote head, cool blue (above). The "cool blue" Yaesu display was eye-pleasing at night.

between the ICOM and Yaesu control heads. On the new ICOM "G series" of 706, ICOM now back-lights all of the keys for nighttime operation. The band up-and-down keys have little arrows on them, and the menu plus "F" keys have designators on them, too. But, in the dead of night, the mode, tuning speed, display, lock, pre-amp, and tuner keys along with RIT simply illuminate, and you will need some background light to see what their use is that has been silkscreened on the panel. Even if ICOM had put a single letter or two on the actual back-lit keys, it would have been better than trying to make out the white silkscreen letters in the dark.

Yaesu does not back-light the front panel, but they DO back-light their mobile microphone. This could allow you to make an autopatch call in the dead of dark, and see the right numbers on the keypad. But for the rest of the display in the dead of night, better go for some back-lighting.

Both Yaesu and ICOM put their most important four keys down at the bottom of the display, and the back-lit LCD display is easily seen in bright daylight or in complete darkness.

The tuning knob on the ICOM is slightly larger and has a bigger finger hole that all of our reviewers liked. The Yaesu knob is slightly smaller and, unless you use your baby finger, it is not as easy to spin the knob with your finger because the finger hole is smaller and doesn't contain the free-spinning insert that ICOM has. ICOM also has a tension adjustment for tightening or loosening the big knob.

The band up-and-down buttons on the ICOM are on the extreme right upper and lower edge of the equipment. They are far enough away from the tuning knob that you won't accidentally bump the knob when pushing the button. On the Yaesu, the up-and-down buttons are just to the left of the tuning knob, and they are relatively close to the tuning knob, so you must use caution when going up and down the bands that you don't accidentally slew off frequency.

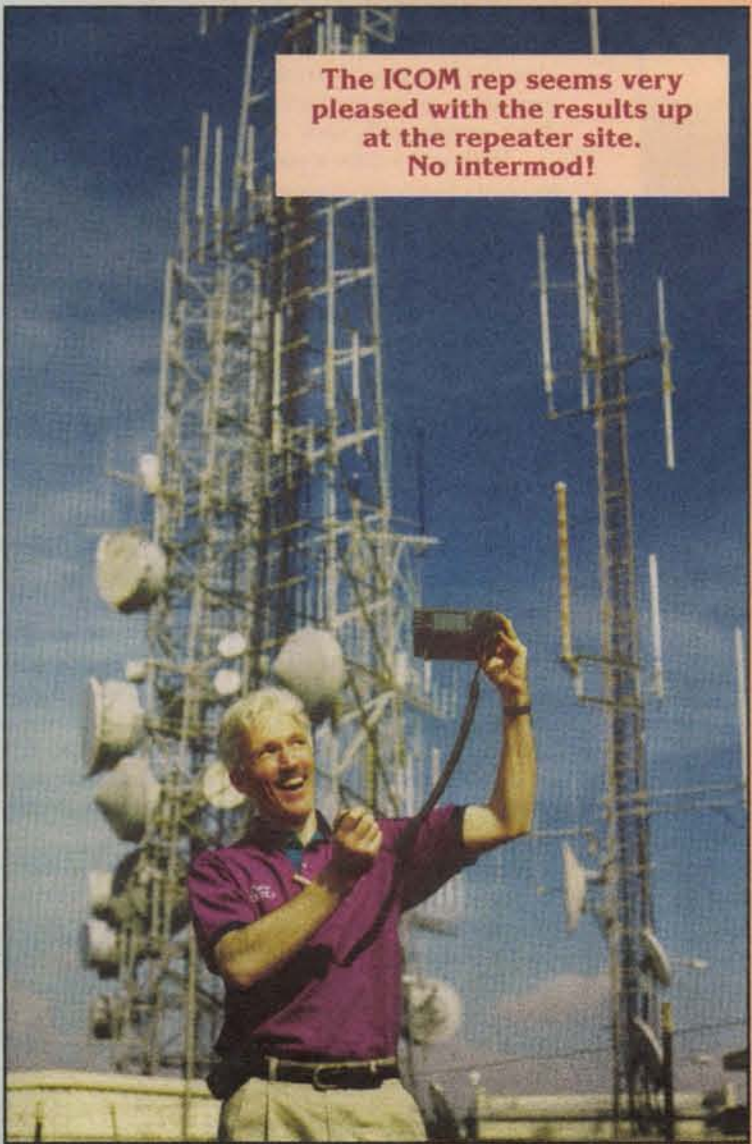
Both units offer a step button that allows you to select the tuning speed. On the Yaesu FT-100, the step speed adjusts the lower left select knob but does not affect the fine-tuning speed on the big knob that is menu-adjustable. On the ICOM, the tuning speed adjustment affects both the main tuning big knob, as well as the small sub-tuning control. But on VHF and UHF weak-signal, single-sideband operation, the Yaesu step button now selects fine-tuning or coarse-tuning of the big knob, and the select knob is set at 10-kHz steps for rapidly going up and down the VHF and UHF weak-signal portions of the band.

On the ICOM 706 MK II G, tuning speed may be selected for fine-tune or coarse-tune by both the big knob, as well as the small select knob. ICOM can show tuning all the way down to one cycle, and the Yaesu FT-100 shows 10-cycle tuning, and is capable of 1.2 cycle tuning by tapping the up or down buttons on the top of the mike. I can't imagine anyone needing this type of tuning resolution, but on both units, it IS available, with each set having its own tuning speed characteristics.

Both the new ICOM and the new Yaesu "DC-to-daylight" transceivers offer a menu setting that allows you to choose RF gain or squelch control off of the inside, top-left, dual-rotating controls. Both sets give you a lock button, and both sets have a keystroke that enables menu items to be selected before you head out on the road.

ALL THOSE MENUS

ICOM has a couple of "regions" of menus inside the equipment. By pressing the menu up to four times, you get 12 items to select. By pressing menu and display, the ICOM now gives



The ICOM rep seems very pleased with the results up at the repeater site. No intermod!

you 12 more items with additional selections among the 12. And press display again, and you get four more items including the band scope, SWR graph, transmit frequency, and capabilities for naming memorized channels.

The ICOM also gives you 37 more menu items by turning off the equipment, and then turning it on while holding the power and the lock button. These are items that you should only need to select once you have figured out how you plan to operate the equipment, and are not ones that you would normally need on the road or while operating the equipment at your shack. However, I wish they had put special menu 4 and 5 as a front-panel push button, because they are useful when driving mobile from dusk to dark and you want to adjust the back-lighting of your display. In fact, I'm amazed that neither the ICOM nor the Yaesu use a relatively inexpensive photocell circuit that automatically dims the display when the photo cell determines there isn't much light on the face of the equipment.

One of the ICOM easy-menu items is digital signal processing. The DSP electronics are now built into the 706 MK II G series, so you won't need to pay extra for it.

An often-used DSP function down on the 40-meter band is the automatic notch filter. If there is a steady carrier that is producing a tone driving you crazy, just push "ANF" and the tone disappears. And if it's just background noise that is occluding a voice or CW signal, press the noise reduction "NR" function, and then select up to 15 levels of noise reduction DSP to pull the signal out. And on the ICOM, it works pretty darn well. As you crank up the level, you can hear the noise disappearing and the signal becoming more intelligible.

On the Yaesu FT-100, they, too, have a host of selections on the front panel via the four push buttons, as well as 66 menu items along with 59 additional secret "factory" menu pre-set adjustments. But before we go into all of the Yaesu menus, let's take a look at Yaesu's digital signal processing that has additional options over the ICOM.

The Yaesu FT-100 offers the customary DSP notch filter that worked great in canceling out a foreign broadcast carrier heterodyne tone. Now push the Yaesu DSP noise reduction feature, and hold the button in that allows you to adjust for 16 levels of noise reduction to enhance incoming weak signals laced with background hash.

And there is more that the Yaesu can do with DSP! The FT-100 has an adjustable DSP bandpass filter where high-cut and low-cut characteristics may be keyboard-changed. This allows you to select high-frequency cutoff, as well as low-frequency cutoff, and tune it to a bandwidth of your choice. And, if you're into CW, you can also adjust the center frequency of the CW DSP peaking filter so the pitch is exactly what you want to hear. The default is 240 Hz, and you can select 120 Hz, or a very narrow 60 Hz.

Both the ICOM and Yaesu DSP circuits worked amazingly well in uncovering weak signals that were buried in powerline noise, as well as hash. If you plan to play around a lot with digital signal processing with a set of headphones, you may find more adjustments with the Yaesu equipment than ICOM. But again, both units worked well in the DSP mode.

Of course, both units also have noise blanking; and if you hold the Yaesu noise-blanker button in, it allows up to 16 adjustments of noise-blanking levels. If you have a particularly noisy vehicle, go for a level that will just take out the sparkplug racket, but don't turn the level any higher because it tends to add distortion to the incoming signal, and may sometimes bring in adjacent frequency QRM. On the ICOM 706 G, the noise-blanker level is set and it appears to be set relatively hot to take out severe sparkplug noise. Both noise blankers were able to keep up with my open-air dune buggy, and that is saying a lot on high frequency.

FROM FRONT TO REAR

There are so many additional menu features that we may need to study each set in detail by going to a radio store live or on the web, and looking over the instruction manuals.

Going to the rear of both the ICOM and Yaesu "DC-to-daylight" transceivers, we see that ICOM — like Yaesu — offers two antenna ports for high-frequency and 50 MHz operation, and the other port for VHF and UHF operation. Both manufacturers go with the SO-239 connector, but Yaesu puts their two connectors on eight-inch pigtails which may facilitate where you mount the equipment and have access to the jacks. Yaesu offers a data output jack, external speaker jack, accessory jack, and a miniature stereo jack for the built-in automatic keyer. ICOM offers two acces-

sory jacks which can be used for data and other inputs and outputs, a second mike jack, an external speaker jack, a LARGE quarter-inch stereo jack for the paddles to go into the built-in keyer, plus a four-pin jack for the matching automatic antenna coupler.

As we mentioned before, the ICOM unit accepts the common six-pin power plug that almost everyone uses in the industry for an HF radio, and Yaesu goes with a pigtailed, big-blade, two-conductor power plug that is unique to this radio only.

Both the ICOM and Yaesu offer "ground-to-transmit" connections that may be used to pull in an external power amplifier, such as the SGC 500 "Power Cube." But if you're running other style high-frequency power amplifiers, such as the old and reliable Mectron and Metrons, you will need to work up an external relay to click the amplifier on. The older amps may draw as much as 250 milliamps of current on their key line, and neither set is capable of supplying this amount of current capability for a lengthy transmission. Both sets will indeed turn on an older amp, but after a few seconds, the internal circuitry will probably zap. Be aware of this!

On the two-meter band, both sets will easily run two-meter COR amplifiers, but another word of caution – you will need to reduce the power output on the two-meter band down to 30 watts, or 10 watts, depending as to what type of amplifier you have. If you try to drive a 30-watt input amp with a 50-watt output that each set has on two meters, something will give, soon. Both ICOM and Yaesu allow for independent two-meter, as well as 440, as well as high-frequency, power-down adjustments.

Incidentally, on the SGC 500-watt amplifier, even though you may have scored an export version that runs carrier-operated relay, I suggest you go inside the amp, flip the switch, and run it off of a key line which helps the equipment during key-up and key-down times without accidentally tripping out of circuit when it may detect a micro-second VSWR anomaly. The SGC amplifier is extremely touchy on SWR, and going to the hard key line will minimize amplifier cycle-out.

OVERALL PERFORMANCE

On VHF and UHF FM, both the ICOM and Yaesu put out an identical 50 watts on two meters, and 20 watts on 440 MHz. On high frequency, both the ICOM and the Yaesu could easily whistle to 125 watts peak, and both sets averaged about the same percentage of power during voice modulation after a bit of tweaking.

Tweaking? On the ICOM 706 G, all of the sideband modes were factory-adjusted with just the right amount of ALC (automatic limiting control) to keep the equipment from over-modulating or flat-topping.

On the Yaesu FT-100, the automatic limiting control on two meters and 440 SSB was similar to the output of the ICOM 706 G, but on high frequency, the factory preset levels didn't give us quite the robust needle swing we saw with the ICOM on our Bird wattmeter. In checking the front meter, it looked like the ALC was set a little high and was throttling back our average power output just a little too much.

A call to the Yaesu factory revealed how easy it was to change ALC settings for each band. The FT-100 SERVICE MANUAL shows how to key-stroke-in factory (only) menu items 01 through 59. Press A, B, and C in on radio turn-on, then menu. Yaesu purposely restricts this information to the technical manual that fully describes what changing some of these items could do for better or worse.

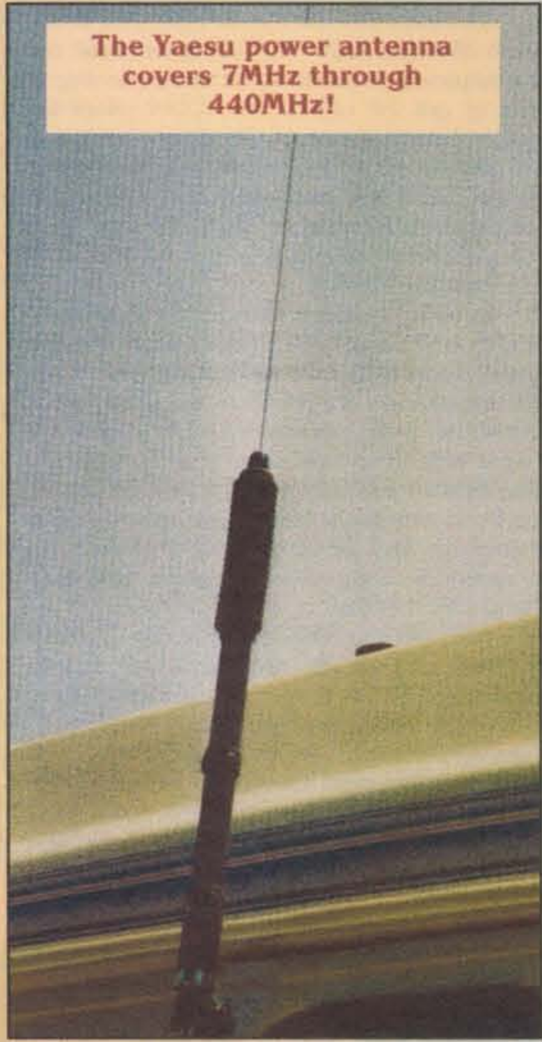
For instance, dialing down the ALC could unleash the transmitter to put out as much as 150 watts, and in no time the radio would get hot as a firecracker and probably go into meltdown. There are also menu items for upping receiver sensitivity on two meters and 440 MHz. Dialing in too much sensitivity on these two bands beyond what the factory has already preset could lead to intermodulation interference in heavy VHF and UHF radio traffic areas.

However, for the more technical amateur operators, buying the optional service manual is something routine where the amateur operator can now – with the Yaesu FT-100 – front dial-in settings to internal circuits that in years past required taking the lid off the radio, and going in with a plastic twiddle stick. This is one of the benefits of digital signal processing – many digital circuits may now be routinely adjusted without having to lift the cover.

Once I slightly readjusted ALC settings to recommendations given me by Chip Margelli K7JA, of Yaesu, I was still within factory specs (on the edge) and the set gave me plenty of output power, nice and linear without any flat-topping, and still continued to run nice and cool during prolonged transmit periods.

Yaesu also gives you a DSP microphone equalizer feature that allowed us to tailor our transmitted audio for exactly how we thought we should sound. Both Yaesu and ICOM also offer speech processing and compression, too.

Both sets included a full-featured, built-in electronic keyer. Both units allowed for setting the weight of your CW exactly as you want it, as well as CW reverse mode and transmit CW pitch. And if you do a lot of CW, you'll enjoy a unique function of the Yaesu FT-100 that has a 50-character message memory storage system to keep


The Yaesu power antenna covers 7MHz through 440MHz!

you from wearing out your fingers during a contest when calling CQ!

The Yaesu I reviewed also had optional CW filters that were soldered in at the factory, and they really work wonders when trying to recover faint signals coming in out of the noise. ICOM optional filters plug in.

Both the ICOM and the Yaesu offer automatic repeater offsets on 10 meters, six meters, two meters, and the 440 MHz bands. I am glad to see this with the new ICOM "G" series because the older equipment required some extra pushing of buttons to get the offset. The ICOM offers full encode and decode as part of their package, and Yaesu offers encode CTCSS only with decode as an option. But Yaesu also offers built-in capabilities of digital code squelch (DCS), and the DCS encoder/decoder is built into the FT-100 as it comes from the factory.

To compare receiver sensitivity and selectivity on HF, VHF, and UHF, I built up an antenna combiner system that would provide one antenna for simultaneous reception on both radios without either radio loading down the circuit. We also went with a two-position antenna switch, but nothing beats the simultaneous reception of both radios to an extremely weak signal on one common antenna. And we tried mobile antennas, big base antennas, long wire antennas, and little VHF and UHF beams.

We tried out the receivers in relatively radio-quiet zones, and we also took both radios up to "mount intermod" that has enough RF coming off of it to just about mesmerize any receiver.

The results are in — both receivers are hot as a firecracker, and both the ICOM, as well as the Yaesu did a fabulous job of sorting out signals among the QRM and QRN. When there was someone on high frequency operating 3 kHz away, both receivers would slightly hear the "buckshot."

Weak signals coming in just about the noise threshold could be received by both receivers, almost identically. But as you would fuss with the DSP circuits, each receiver had its own characteristic way of pulling out signals really down in the mud. And same thing for CW — when we switched to the more narrow CW filters, they did the job well with the Yaesu equipment. Had we installed the optional CW filters in the ICOM gear, it would have probably given us the same CW results.

While you'll probably hear reports about one receiver being far superior than the other, we could barely tell a difference during our operating tests — both were outrageously sensitive, selective, and AGC (automatic gain control) action was about the same. When we would set the squelch on HF SSB, and a weak signal would break through the squelch, you would hear it come over both rigs at the same time.

THE WINNER IS ...

So who is the winner of the DC-to-daylight radios from ICOM and Yaesu? WE, as the buying public, are the winners because manufacturers have packed in so much that originally took three radios a few years ago to do. We win big time when it comes to the capabilities of both of these transceivers, and I really couldn't say which one was "better" than the other — they both were great.

Which one YOU will choose depends on how you like the sound and feel of the equipment. Try to work the two pieces of equipment, as we did, side by side off of a common or antenna one/antenna two selector switch. Don't worry about your transmit audio — everyone will love it on either radio. But listen for yourself, try the push buttons, and then get the "feel" for how each radio operates. Learn everything you can about the equipment to discover advantages of one over the other.

We discovered that Yaesu has a matching mobile antenna that covers 40 meters through 440 MHz, and is motor-driven-adjustable by an automatic built-in tuner inside both the radio and the antenna. Just push the button and the Yaesu ATAS-100 antenna goes up and down, stopping at exactly the lowest SWR point. For VHF and UHF, it drops all the way down into the nested position to provide one-quarter wave on two meters, and three-quarter wave on 440 MHz with appropriate impedance matching. On HF, it is a loaded quarter-wave that automatically tunes within a few seconds of pushing the tune button. Sorry, no 75 meter or 160 meter automatic operation.

On the ICOM, we discovered that you could run both headphones or an external speaker off of the remote control front panel. We found a little switch that selected this option. It was probably somewhere in the instruction manual, but nothing beats working with the equipment when you have it out of the box, and right in front of you.

So do just that—find these two rigs, out of the box, turned on, right in front of you, and do as we did and give them a side-by-side comparison. Choosing which one is for you will be one tough decision — you indeed are the winners with this new technology of a transceiver that gives us DC-to-daylight coverage! **NV**

Continued from page 42

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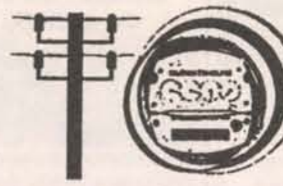

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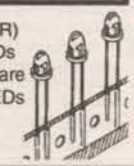

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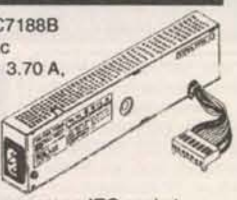

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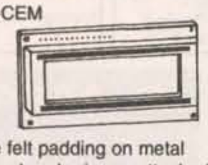

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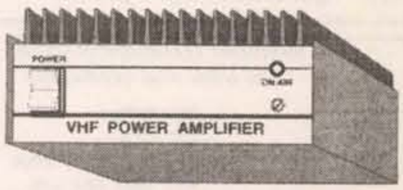

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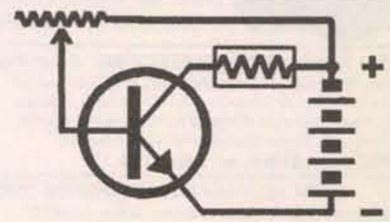

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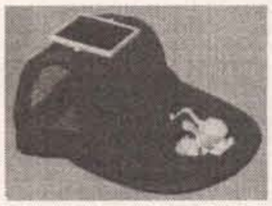

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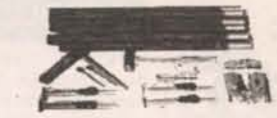

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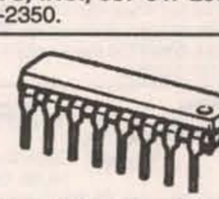

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HP 5370A 100MHZ U.T.I. COUNTER	$400.00	LECROY 7200 400MHZ O-SCOPE	$1000.00
HP 3586C LEVEL METER	$750.00	TEK 475 200MHZ O-SCOPE	$500.00
HP 436A POWER METER W/O SENSOR&CABLE	$500.00	TEK 465 100MHZ O-SCOPE	$400.00
HP 8350B SWEEP OSCILLATOR MAINFRAME	$2000.00	TEK 496P 1KHZ-1.8GHZ SPEC.ANALYZER	$3500.00
HP 3437A 3.5DIGIT SYSTEM VOLT METER	$250.00	TEK 1240 LOGIC ANALYZER	$750.00
HP 3455A DIGITAL MULTIMETER	$250.00	TEK TDS320 100MHZ DIGITAL O-SCOPE	$1400.00
HP 3456A DIGITAL MULTIMETER	$400.00	TEK 11401A 500MHZ PROG.0-SCOPE FRAME	$750.00
HP 3336C SYNTHESIZER/LEVEL GENERATOR	$800.00	TEK 7854 400MHZ OSCILLOSCOPE FRAME	$500.00
HP 3325A SYNTHESIZER/FUNCTION GENERATOR	$1000.00	TEK 7904 400MHZ OSCILLOSCOPE FRAME	$250.00
HP 5335A 200MHZ COUNTER	$600.00	TEK 7A26 200MHZ VERTICAL PLUG	$75.00
HP 8165A PROGRAMMABLE SIGNAL SOURCE	$1100.00	TEK 7A24 400MHZ VERTICAL PLUG	$150.00
HP 8558B/181 100K-1500MHZ SPECTRUM ANALYZER	$1000.00	TEK 7B80 400MHZ TIME BASE	$75.00
HP 8559B/183 10MHZ-21GHZ SPECTRUM ANALYZER	$3000.00	TEK 7B92A 500MHZ DUAL TIME BASE	$125.00
HP 1740A 100MHZ OSCILLOSCOPE	$250.00	TEK 7S12 SAMPLING PLUG	$250.00
HP 6034A 60VDC-10A POWER SUPPLY	$750.00	TEK 7L14 10KHZ-1.8GHZ SPEC. ANALYZER	$1000.00
HP 6269B 40VDC-50A POWER SUPPLY	$800.00	TEK AM503 CURRENT PROBE AMPLIFER	$250.00
HP 6553A 40VDC-12.5A. POWER SUPPLY OPT.J01	$1200.00	WAVETEK 145 20MHZ PULSE/FUNCTION GEN.	$400.00
HP 6632A 20VDC-5A POWER SUPPLY	$500.00	WAVETEK 182A 4MHZ FUNCTION GEN.	$150.00
HP 6643A 45VDC-4.3A POWER SUPPLY OPT.JO3	$750.00	WAVETEK 955 7.5-12.4GHZ MICROSOURCE	$1100.00

Write in 115 on Reader Service Card.

WANTED: TUBE HiFi/commercial amps, preamps, corner/horn speakers. Altec, Marantz, McIntosh, Western Electric, etc. 405-737-3312 fax 405-737-3355.

WANTED: TUBES, radios, transmitters, receivers, gyros, bearings, connectors, relays, lamps, synchros. Hyness Company, 709B Delair Road, Cranbury, NJ 08512-4212. Phone: 609-395-1116, FAX 609-395-1117.

WANT USED or surplus DC motor controls or adjustable frequency AC drives, 1/2 HP and up. DC motors fractional to 3 HP. C. Woodruff, 5507 55th Ave. S., Seattle, WA 98118. Voice/Fax 206-723-8487.

CASH PAID FOR ICs. Military or commercial integrated circuits, transistors, diodes, any semiconductors. **ELECTRONIC SURPLUS, INC.**, 5363 Broadway, Cleveland, OH 44127. 216-441-8500 or fax 216-441-8503, since 1946. www.electronicsurplus.com

WESTERN ELECTRIC wanted: 1920s-1960s. Amplifiers, mixers, pre-amps, speakers, tubes, etc. FREE OFFER 1-800-251-5454.

WANTED: OLDER electronics and computer magazines. Popular Electronics, Radio-Electronics, Byte, DDJ, Kilobaud, Creative Computing, Computer Hobbyist, group newsletters, etc. Call Shawn, 650-846-8208, maxweb@pacbell.net

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Features high performance AC/DC voltage and current measurement, frequency, duty cycle, resistance, conductance, and capacitance measurement.

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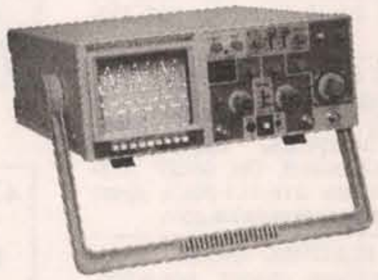

S-1325	25MHz	Dual Trace	$325
S-1330	25MHz	Delayed Sweep	$439
S-1340	40MHz	Dual Trace	$475
S-1345	40MHz	Delayed Sweep	$569
S-1360	60MHz	Delayed Sweep	$749
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DS-303	40MHz/20Ms/s Analog/Digital	$995
DS-603	60MHz/20Ms/s Analog/Digital	$1295

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Model GF-8036

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Sensitivity:
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- <5mV @ 250MHz
- <5mV @ 1GHz
- <100mV @ 2.4GHz

Features 10 digit display, 16 segment and RF signal strength bargraph.

Includes antenna, NiCad battery, and AC adapter.

B&K Frequency Counter
Model BK-1875

.1Hz - 2.8GHz
3 Channels

$189

Sensitivity:
- <0.8mV @ 100MHz
- <6mV @ 300MHz
- <7mV @ 1GHz
- <100mV @ 3GHz

Ultra sensitive synchronous detector bargraph and RF strength.

20MHz Sweep / Function Generator with Frequency Counter
Model 4040

$399

- 0.2Hz to 20MHz
- AM & FM modulation
- Burst Operation
- External Frequency counter to 30MHz
- Linear and Log sweep

BK PRECISION

10MHz Model 4017 $309
5MHz Model 4011 $239

Elenco RF Generator with Counter (100kHz - 150kHz)
Model SG-9500

Features internal AM mod. of 1kHz, RF output 100MV - 35MHz. Audio output 1kHz @ 1V RMS.
SG-9000 (analog, w/o counter) $119.95

Elenco 10Hz - 1MHz Digital Audio Generator
Model SG-9300

$175

Features built-in 150MHz frequency counter, low distortion and sine/square waves. **SG-9200 (w/o counter) $119.95**

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Elenco Model MX-9300

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Features:
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  - Digital Multimeter
  - Digital Triple Power Supply - 0-30V @ 3A, 15V @ 1A, 5V @2A

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Pro-Sport FRS Two-Way Radio
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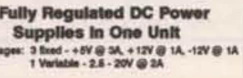

4 Fully Regulated DC Power Supplies In One Unit
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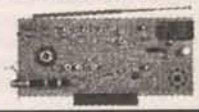

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Radio Control Car Kit

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- Radio Control Included

Model M-1005K
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Events CALENDAR

Continued from page 24

E-Mail: n2xyz@sjra.org Web: http://www.sjra.org
NY - HORSEHEADS - Hamfest. Chemung County Fairgrounds. 6am-3pm. FCC Exams. Talk-in: 147.96/36, 444.20. ARAST, Dave Lewis, 607-589-7495. E-Mail: info@arast.org hamfest@arast.org or winterfest@arast.org
WA - WALLA WALLA - Hamfest. Walla Walla Valley ARC, Jack Babbitt, Sr. WA5ZAY, 509-525-7003. E-Mail: wa5zay@valint.net

SEPTEMBER 25-26

AK - ANCHORAGE - Hamfest. Anchorage ARC, Rick Marvin KL7YF, 907-277-6741. E-Mail: rlment@alaska.net
IL - GRAYSLAKE - Radio Expo '99. Lake County Fairgrounds, Rts. 45 & 120. Sat: 8am-4pm, Sun: 8am-3pm. VEC Testing. Talk-in: 146.16/76 MHz (107.2 Hz PL). Chicago FM Club, Mike Brost WA9FTS, 708-457-0966 (Voice Mail/Fax). Web: http://www.chicagofmclub.org
NH - LANCASTER - Hamfest. Lancaster Fairgrounds, Rt. 3 North. 9am. VE Exams. Talk-in: 145.430 & 145.150 & 147.315. Moose Swappers, Russ Boyce N1YZE, 603-922-5514. E-Mail: cusvt@together.net

SEPTEMBER 26

CA - SANTA ANA - Swapmeet. ACP parking lot. Mary Russo 714-558-8813
CO - LONGMONT - Hamfest. Boulder ARC, Randy Cassingham K0RCC, 303-664-5366. E-Mail: arcie@thisistrue.com Web: http://www.thisistrue.com/barc.html
FL - NEW PORT RICHEY - Hamfest. Recreational Center. 9am-3:30pm. Talk-in: 145.35 & 147.15. SARC, Mike Whitmore WB8ONY, 727-934-0228
MA - FRAMINGHAM - Hamfest. High School. FARA, Bev N1LOO, 508-626-2012
MD - BOWIE - FARFEST '99. Prince George's Stadium, Rt. 301, 1/4 mi S of Rt. 50. 6am (tailgate). VE Exams. Talk-in: 147.075 & 146.52. Foundation for Amateur Radio, Al Brown KZ3AB, 301-490-3188, Mary Morris N4TCI, 703-971-3905. E-Mail: Al Brown@ix.netcom.com E-Mail: amateur radio@hotmail.com Web: http://www.amateurradio-far.org
NC - BUTNER - Hamfest. Falls Lake ARC, Wiley Ayscue N4NCK, E-Mail: n4nck@bellsouth.net http://www.angelfire.com/nc/n4nck/flarc.html
NY - YONKERS - Flea Market. Lincoln High School, Kneeland Ave. 9am-3pm. VE Exams. Talk-in: 440.425 PL 156.7, 223.760 PL 67.0, 146.910, 443.350 PL 156.7. Metro 70cm Network, Otto Supliski WB2SLQ, 914-969-1053
OH - BEREA - Hamfest. Cuyahoga County Fairgrounds. 8am-2pm. VE Exams. Talk-in: 146.73- PL110.9. Hamfest Assn. of Cleveland, Ron Nichols N8LZA, 1-800-CLE-FEST or 216-999-7388. E-Mail: info@hac.org Web: http://www.hac.org

OCTOBER 1999

OCTOBER 1

WI - RACINE - Auction. Racine Megacycle Club, Rob Madson KF9ZT, 414-552-6RMC. E-Mail: w9udu@wi.net Web: http://ww2.wi.net/~hamradio.

OCTOBER 1-2

AR - SPRINGDALE - Hamfest. Northwest AR ARC, Clarence Morrow KC5UEW, 501-631-9231

OCTOBER 1-2-3

CA - LONG BEACH - ARRL Southwestern Division Convention. Nate Brightman K6OSC, 562-427-5123.

OCTOBER 2

CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052
FL - MAITLAND - Hamfest. Bahia Shrine AR Unit, Cecil Morehouse K4KEN, 407-281-9169
MO - WARRENSBURG - Hamfest. Warrensburg Area ARC, Keith Haye WE0G, 816-697-3426. E-Mail: we0g@microlink.net
NJ - LEONARDO - Hamfest '99. Croydon Hall, Leonardville Rd. east of Hosford Ave. 8am. VE Exams. Talk-in: 145.485 (-). Middletown Township OEM & Garden State ARA, Mario Sellitti N2PVP, 732-787-7184. E-Mail: gsara@monmouth.com Web: http://www.monmouth.com/~gsara
NY - SYRACUSE - Hamfest. Pompey Hills Fire Dept., off Rt. 20. 8am-2pm. Talk-in: 147.90/30. RAGS, Vivian Douglas WA2PUU, 315-469-0590. Web: www.pagesz.net/~rags
PA - LEWISBURG - Computer, Amateur Radio & Electronics Show & Flea Market. Silver Moon Antique & Flea Market Show Area. Rt. 15, 2.3 mi N of Rt. 45. 9am-4pm. Talk-in: 147.270 Repeater & 146.52 simplex. Susquehanna Valley ARC, George Machesic 570-286-2086. E-Mail: gpmac@netscape.net, Dave Welker k3si@hotmail.com Web: http://loveland.dynip.com/svarc
SC - ROCK HILL - Hamfest & Computer Fair

OCTOBER 3

NY - QUEENS - Hamfest. Hall of Science parking lot, Flushing Meadow Park Corona, 47-01 111th St. 9am-3pm. Talk-in: 444.200 repeat, PL 136.5, 146.52 simplex. Hall of Science ARC, Stephen Greenbaum WB2KDG, 718-898-5599. E-Mail: WB2KDG@Bigfoot.com
PA - WRIGHTSTOWN - Hamfest. Mt. Airy VHF RC, Mark Schreiner NK8Q, 610-847-2285. E-Mail: nk8q@amsat.org Web: http://www.ij.net/packrats/l

OCTOBER 8-9

FL - STARKE - Hamfest. Bradford County Fairgrounds, US 301 N. Fri: 2pm-8pm, Sat: 8am-4pm. Talk-in: 145.150-. Bradford Area ARC, Walt Terrell 904-755-4964 or Tony Spatafore 904-964-9328. E-Mail: wb2fgl@techcomm.net Web: www.angelfire.com/fl/arcba/index.html
NH - ROCHESTER - Hamfest. Fairgrounds. Hoss Traders, Joe, 207-469-3492

OCTOBER 8-9-10

CA - BAKERSFIELD - Hamfest. Bakersfield ARA, Robert Gerner Jr. KB6JFL, 661-588-7065. E-Mail: w6bar@hotmail.com Web: http://members.tripod.com/~w6bar/bara.html

OCTOBER 8-9-10-11

CA - SAN DIEGO - 17th Space Symposium & AMSAT-NA Meeting. Duane Naugle KO6BT, 619-273-4088. E-Mail: ko6bt@amsat.org Web: http://www.amsat.org

OCTOBER 9

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves
GA - AUGUSTA - Hamfest. ARC of Augusta, Terry Brown KE4MHN, 706-796-1128. E-Mail: cookie4u@cheerful.com Henry Arostegui KN4AV, 706-793-1625, E-Mail: kn4av@bellsouth.net Web: http://www.gabn.net/kd4ahqweather/arca.html
WA - BREMERTON - Hamfest. President's Hall, Kitsap County Fairgrounds. License Exams 10am. Talk-in: WW7RA repeater 146.620-, tone 103.5, simplex 146.520. North Kitsap ARC, Marcie Stilwell, 360-697-2797. E-Mail: nkarc@yahoo.com

OCTOBER 9-10

FL - TAMPA - Hamfest. 4050 Dana Shore Dr. Sat & Sun 9am-3pm. Egypt Temple ARA, George Dixon 813-933-4350; Len Smith 813-684-4408; Larry Padgett 813-948-6500, E-Mail: kf4iti@ij.net
TN - MEMPHIS - Memfest '99.

OCTOBER 10

CT - WALLINGFORD - Connecticut State ARRL Convention. Mountainside Special Event Facility, High Hill Rd. 9am-3pm. Nutmeg CT Conv. Nutmeg Hamfest Alliance, Gordon Barker K1BIY, 860-342-3258 E-Mail: k1biy@juno.com. E-Mail: nutmeghamfest@qsl.net Web: http://www.qsl.net/nutmeghamfest
MD - WEST FRIENDSHIP - CARA Hamfest. Howard County Fairgrounds, S of I-70, E of Rt. 32. 8am-3:30pm. VE Exams. Talk-in: 147.135 (-) repeater, 146.52 simplex. CARA, 410-796-2587. Web: http://www.ocbs-nt-server.umaryland.edu/cara/hamfest.htm
MI - MASON - Hamfest. Central MI ARC & Lansing Civil Defense Repeater Assn., Don Tillitson WB8NUS, 517-321-2004. Web: http://www.qsl.net/cmarc/hamfair-html
NC - MAYSVILLE - Hamfest.
OH - LIMA - Hamfest. Northwest OH ARC, Greg Schwark N8WBD, 419-647-6321. E-Mail: gas1950@aol.com

OCTOBER 15-16

MS - BILOXI - Hamfest. MS Coast ARA, Wayne Miller KB5AAU, 228-539-9929. E-Mail: kb5aau@worldnet.att.net Web: http://www.ametro.net/mcara

OCTOBER 15-16-17

CA - CONCORD - Hamfest. Mt. Diablo ARC, Dick Brown KT6X, 925-676-9048. E-Mail: paccon99@pacbell.net

OCTOBER 16

CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052
IL - GODFREY - Hamfest. Lewis & Clark RC, Harold Elmore N9HE, 618-466-1909. E-Mail: helmore@piasanet.com Web: http://www.ezl.com/~lmiller/lcrc.html
MT - BOZEMAN - Hamfest. Gallatin Ham Radio Club, Laura Marino Lubner KJ7UN, 406-586-6659. E-Mail: ghrc@bigfoot.com Web: http://ghrc.webjump.com
TN - GRAY - Hamfest. Appalachian Fairgrounds, off I-181. Kingsport, Bristol, and Johnson City

Events CALENDAR

Radio Clubs, POB 3682 CRS, Johnson City, TN 37602

TX - DENTON - Hamfest. Denton County ARA, Don Mathis KB5YAM, 972-292-1203. E-Mail: dmathis@lsic.net. Web: http://lsic.net/dhf

OCTOBER 16-17

FL - PALM BEACH GARDENS - Hamfest. AMARA Shrine Temple, 3650 RCA Blvd. Sat: 9am-4pm, Sun: 9am-2pm. Talk-in: 147.165/147.765. Palm Beach Repeater Assn., Ken Summerell KD4CTG, 561-640-9447. E-Mail: sum@flinet.com

OCTOBER 17

MA - CAMBRIDGE - Flea at MIT. Albany and Main Sts. 9am-2pm. Talk-in: 146.52 & 449.725/444.725 W1XM/R PL 114.8 (2A). Nick Altenbernd KA1MQX, 617-253-3776 (9-5). Web: http://web.mit.edu/w1mx/www/swapfest.html

MI - KALAMAZOO - Hamfest. County Fairgrounds. Talk-in: 147.040 K8KZO. Kalamazoo ARC & SW MI AR Team, E-Mail: ka8blo@net-link.net Web: http://www.qsl.net/ka8blo/hamfest.html

OH - ASHLAND - Hamfest. County Fairgrounds, Claremont Ave. 8am-2pm. Talk-in: 147.105+, 71.9PL. Ashland Area ARC, David Fike N8UCA, 419-289-1082, daytime. Mike Stroub KC8LCH, 419-945-2777, nighttime. E-Mail: aaarc@hotmail.com

PA - SELLERSVILLE - Hamfest. NEW Sellersville Fire House, Main St. Bethlehem Pike. 7am-1pm. VE Exams. Talk-in: 145.31 (144.71 input) W3AI repeater. R. F. Hill ARC, Linda Erdman KA3TJZ, 215-679-5764. Web: http://www.rfhill.ampr.org

WA - CHEHALIS - Hamfest. The Southwest Washington Fairgrounds. Talk-in: 147.06+ 110.9 pl, simplex 146.46. Chehalis Valley ARS, Jim Kruger KK7AB, 360-748-1930; KK7AB@ARRL.net or Bill Harwell KC7QHJ, 360-748-8086. E-Mail: bharwell@localaccess.com Web: http://www2.localaccess.com/teaser/cvars/

OCTOBER 23

LA - LAKE CHARLES - Hamfest. Southwest LA ARC, Dick Rogers WB5TUG, 318-474-7947. E-Mail: hotred@linknet.net

NH - NASHUA - Hamfest. Res Ctr Church, Antique RC, 617-923-2665

OR - RICKREALL - Swap-Toberfest. Polk County Fairgrounds. 9am-3:30pm. Talk-in: 146.86-. Mid-Valley ARES, Bob Boswell, W7LOU 503-623-2513, E-Mail: w7lou@goldcom.com Web: http://www.teleport.com/~n7ifj/swaptobe.htm

TN - CHATTANOOGA - Hamfest. C. Jordan in E. Ridge. Chattanooga ARC, David Hoffman KE4FGW, 423-877-7398. E-Mail: w4am@qsl.net Web: http://www.qsl.net/w4am

OCTOBER 24

IN - LEBANON - Hamfest. Boone & Clinton County ARC, Sara Leckliitner KB9OEZ, 765-482-9152.

MD - WESTMINSTER - Mason-Dixon Computer & Hamfest. Carroll County Ag Center. 8am. VE Exams. Talk-in: 145.410 CCARC Repeater. Carroll County ARC, Wayne Wilson N3UN, 410-795-2556 (ph/fax). E-Mail: k3pzn@qis.net. Web: http://www.qis-net/~k3pzn

MI - WARREN - Hamfest. Utica Shelby Emergency Comm. Assn. Debbi Cokewell KB8YYB, 810-263-0227. E-Mail: cuer@juno.com Web: http://www.useca.org

NY - LINDENHURST - Hamfest. Great South Bay ARC, Tom Carrubba KA2D, 516-422-9594. E-Mail: info@gsbarc.org Web: http://www.gsbarc.org

PA - GREENSBURG - Hamfest. 8am-2pm. Talk-in: 147.180+. Foothills ARC, Jim Yex WB3CQA, 724-864-6228. Web: http://www.geocities.com/Heartland/Acres/7896/

OCTOBER 29-30

FL - JACKSONVILLE - Greater Jacksonville Amateur Radio & Computer Show. Morocco Shrine Auditorium, 3800 South St., Johns Bluff Rd. Fri: 1-8pm, Sat: 9am-5pm. VE Exams. Greater Jacksonville Hamfest, Woody Parker KF4GSK, 904-743-3121. E-Mail: sbarber@mediaone.net. Web: http://www.ccse.net/~lrich/hamfest98.htm

OK - KINGSTON - Hamfest. Texoma Hamarama, Herb Sleeper WB5PHM, 940-855-5820. E-Mail: retmarine@cst.net Web: http://www.qsl.net/kc5sig/hamarama

OCTOBER 30

MN - ST. PAUL - Hamfest. The New RiverCentre. 8am-4pm. VE Exams. Twin City FM Club, Dale Reak KB0VCV, 612-687-9535. Web: http://www.hamfestmn.org

OCTOBER 31

MO - ST. LOUIS - Hamfest. St. Louis ARC & Gateway to Ham Radio Club, Steve Welton WB0IUN, 314-638-4959. E-Mail: slw@partyline.net
OH - MARION - Hamfest. Marion ARC, Karen Eckard N8KE, 740-499-3565. E-Mail: meeker@gte.net
OH - MASSILLON - Hamfest. Stark County Fairgrounds. Talk-in: 147.18+ & 442.85. Massillon ARC, Don Wade W8DEA, 330-497-7232. E-Mail: marc.hamclub@juno.com

NOVEMBER 1999

NOVEMBER 6

CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052
FL - SORRENTO - Hamfest. East Lake Chamber of Commerce Bldg. VE Exams. Talk-in: 147.255. Lake ARA, John Wentz W8HFK, 352-728-2615. E-Mail: capias@gate.com Chuck Crittenden KE4EXM, 352-669-2075
IN - FORT WAYNE - Hamfest & State Conv. Allen County War Memorial Coliseum Expo Center. Sat: 9am-4pm, Sun: 9am-3pm. Talk-in: 146.88-. ACARTS, 219-484-1314. Web: http://www.pipeline.com/~dagagnon/
NH - MANCHESTER - Hamfest. St. John Church. IRS, Paul K1LLX 603-432-1538. E-Mail: K1LLX@juno.com
SC - MYRTLE BEACH - Beachfest '99. Old Myrtle Beach Air Force Base. 7am-2pm. Talk-in: 147.120 +600. Grand Strand ARC, Jim Wood KF4CJE, 843-238-0800. E-Mail: kf4cje@juno.com Web: http://www.w4gs.org

NOVEMBER 6-7

GA - LAWRENCEVILLE - Hamfest. Gwinnett County Fairgrounds. Talk-in: 145.45- (PL 107.2), 444.25+ (PL131.8), 146.76- (PL 107.2). Alford Memorial RC, Hotline: 770-410-3989. E-Mail: hamfest@totrbbs.radio.org
TX - ODESSA - Hamfest. West Texas ARC, Robert Jordan N5RKN, 915-335-7980. E-Mail: n5rkn@apex2000.net Web: http://nonprofit.apex2000.net/hamfest/

NOVEMBER 7

KY - HAZARD - Swapfest. Hazard High School
MI - ST. JOSEPH - Hamfest. Blossomland ARA, Duane Durflinger KX8D, 616-982-0404. E-Mail: comdac@comdac.com Web: http://www.comdac.com/bara
WI - KAUKAUNA - Hamfest. Starlight Club. VE testing. Talk-in: 146.52 simplex. Fox Cities ARC, Chad Pennings N9PRC, 920-993-0485. E-Mail: n9prc@kb9byq.ampr.org Web: http://www.w9zl.ampr.org

NOVEMBER 13

AL - MONTGOMERY - Hamfest. Montgomery ARC, Arthur Price KF4ILP, 334-272-2681. E-Mail: kf4ilp.arthur@worldnet.att.net Web: http://jschool.troyst.edu/~w4ap/
CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves
NM - SOCORRO - Hamfest. Socorro ARA, Al Braun AC5BX, 720 California St., Socorro NM 87801

NOVEMBER 13-14

IN - FORT WAYNE - IN State ARRL Convention & Hamfest. Allen County AR Technical Society, Doug Jones N9NNT & Jim Boyer KB9IH, 219-484-3317. E-Mail: djones2233@aol.com Web: http://www.pipeline.com/~dagagnon/

NOVEMBER 20

CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052
MA - NEWTONVILLE - Auction. Masonic Hall, second floor, 460 Newtonville Ave. 11am-4pm. WARA/1200 RC, Eliot Mayer W1MJ, 617-484-1089. E-Mail: W1MJ@amsat.org

NOVEMBER 20-21

FL - TAMPA - Suncoast Hamfest, FL State ARRL Convention. State Fairgrounds, Expo Hall. Florida Gulf Coast Amateur Radio Council, Jean Endicott KC4KZU, 727-525-5178. E-Mail: swaps@fgcarc.org Web: http://www.fgcarc.org

NOVEMBER 27

NC - GREENSBORO - Hamfest. Greensboro Coliseum Special Events Center. GGH, 336-851-1676. Web: http://www.sabwc.com/gsohamfest

NOVEMBER 28

CA - SANTA ANA - Swapmeet. ACP parking lot. Mary Russo 714-558-8813
NY - PATCHOGUE - Hamfest. Mid-Island ARC, Mike Grant N2OX, 516-736-9126. E-Mail: global-cm@erols.com Web: http://www.qsl.net/mid-islandarc/hamfest.html

DECEMBER 1999

DECEMBER 4

CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

DECEMBER 11

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves
SC - UNION - Hamfest. Armory. Union County ARC

DECEMBER 18

CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-005

JANUARY 2000

JANUARY 8

WI - WAUKESHA - Hamfest. West Allis RAC, Phil Gural W9NAW, 414-425-3649.

JANUARY 9

IN - SOUTH BEND - Hamfest. Michiana Valley Hamfest Assn., Bob Denniston KA9WNR, 219-291-0252

JANUARY 15-16

FL - SARASOTA - Hamfest. Sarasota ARA, William Eddie Martin KI4ZJ, 1870 Bahia Vista St., Sarasota FL 34239-2201

JANUARY 16

NY - YONKERS - Flea Market. Lincoln High School, Kneeland Ave. 9am-3pm. VE Exams. Talk-in: 440.425 PL 156.7, 223.760 PL 67.0, 146.910, 443.350 PL 156.7. Metro 70cm Network, Otto Supliski WB2SLQ, 914-969-1053

JANUARY 22

NH - NASHUA - Hamfest. Res Ctr Church. NE Antique RC 617-923-2665

FEBRUARY 2000

FEBRUARY 26

VT - MILTON - NVT Winter Hamfest. High School, Rt. 7. Mitch W1SJ, 802-879-6589

FEBRUARY 27

FL - ZEPHYRHILLS - Hamfest. Zephyrhills ARC, Ernie Vanselow KD4VRV, 813-783-8389 E-Mail: kd4vrv@gte.net

by Joseph J. Carr

Open Channel

Notes on Vibration Detectors and Seismographs — Part 2

This month, we will look at a clever sensor that can be used for earthquake detection.

Last month, we looked at various vibration sensors. Most of those instruments are intended to measure large vibrations, so they are not really too useful for making an amateur seismograph project (although a couple of them could be used for that purpose). This month, we will look at a clever sensor that can be used for earthquake detection.

Lehman-Type Seismometer Project

The Lehman Seismometer was designed by Dr. James D. Lehman of the Department of Physics at James Madison University in Harrisonburg, VA. It was the subject of the "Amateur Scientist" column written by Jearl Walker in *Scientific American* (July 1979, p. 152ff). This seismometer is said to be capable of detecting earthquakes of 4.8 or more on the Richter scale in the United States, and 6.0 or more in other areas of the world.

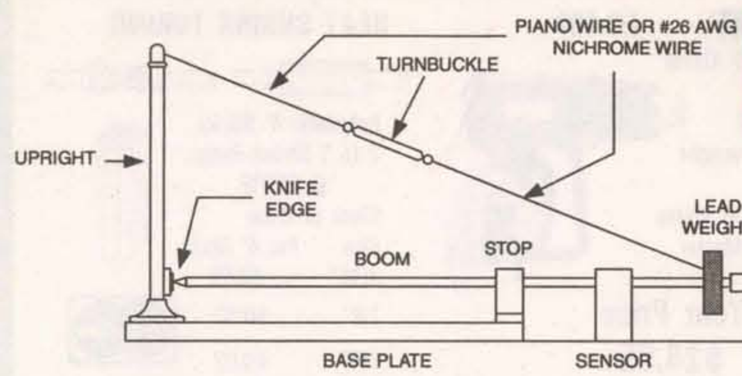


Figure 2 - Lehman seismometer (side view).

The plan (top) view is shown in Figure 1, while a side view is shown in Figure 2. A long (75-cm or more) pendulum boom made of 5/16-inch (8-mm) stock is suspended from an upright section (Figure 3) such that its "knife edge" butt end rests against a strike plate on the upright section. The last 20-cm or so of the boom is threaded to accept a 5/16-20 or finer hex nut. When side-to-side vibrations characteristic of an earthquake are present, the pendulum arm will swing back and forth in the horizontal plane. A pair of stops (Figure 4) are used to prevent over-travel of the pendulum boom arm. The components of the seismometer are mounted on a flat base plate. This plate can be made of aluminum, wood, or plastic, but it must be level and stable. Do not use thin material (less than 1.5 cm) for the base.

The upright segment is made from copper plumbing pipe, right angle joints, and a pair of universal flanges for mounting to the base plate. The overall height is about 46 cm. A lower cross piece holds the strike plate, while the upper cross piece holds a special wire attachment point fixture (more on this shortly).

In Figure 2, you saw the side view. The wire suspending the boom is either piano wire or #26 AWG nichrome wire. A small turnbuckle is used to make the wire taut and level the boom. The upper end of the suspension wire is tied off to the upper cross piece (Figure 5). The Walker article used an oil burner furnace nozzle to precisely position the suspension wire.

Detail in plan view of the lower cross piece is shown in Figure 6. The cross piece can be machined from a bar of aluminum or brass, although some have made it out of plastic (not recommended, I am told). The ends of the cross piece are beveled to allow it to be mounted to the vertical upright members. In the center of the cross piece is the strike plate assembly. Detail for the strike plate itself is shown inset. A 1/4-inch carriage bolt or other flathead

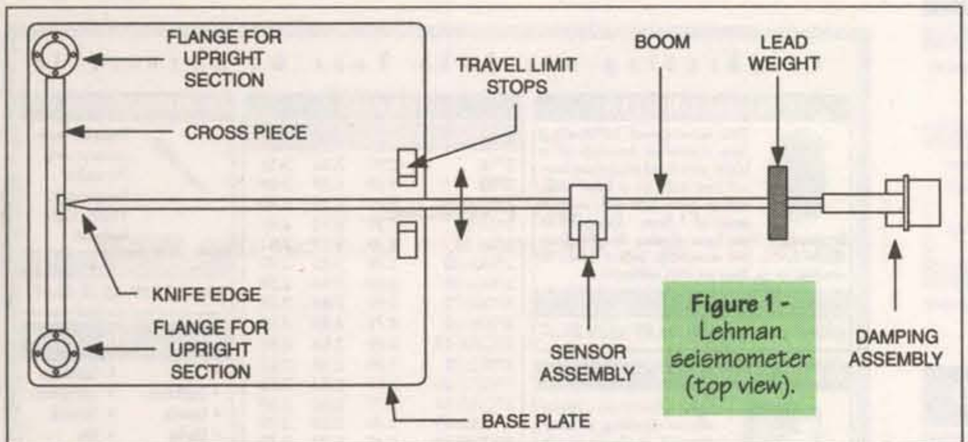


Figure 1 - Lehman seismometer (top view).

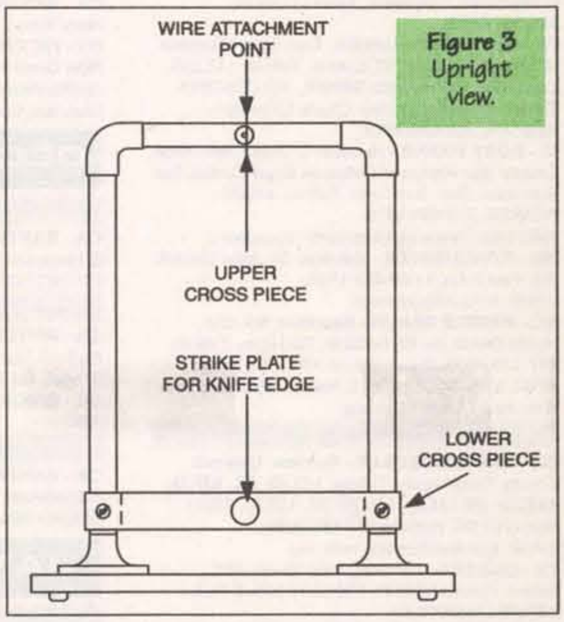


Figure 3 Upright view.

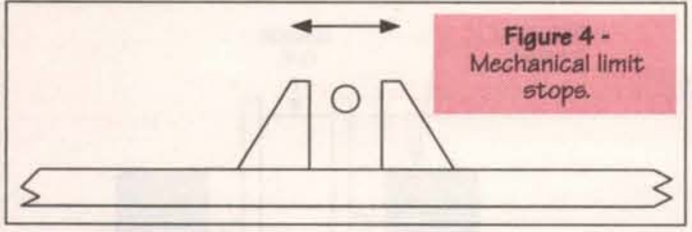


Figure 4 - Mechanical limit stops.

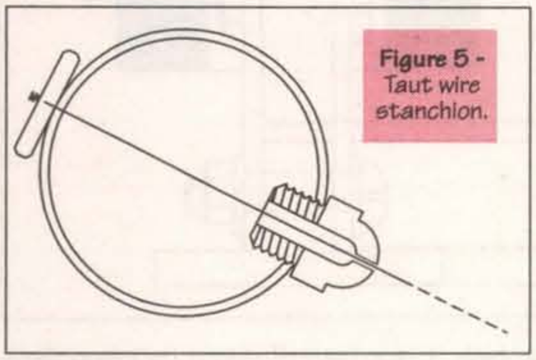


Figure 5 - Taut wire stanchion.

machine bolt is used to make the strike plate. It is cut off from the threaded segment, leaving only the head and the unthreaded portion of the shank. The head is machined flat and polished. This makes a nice, low friction surface for the knife edge end of the pendulum boom.

A hole is drilled through the cross piece just slightly larger than the strike plate. A 1/4-20 (or finer) hex nut is soldered or glued to the backside of the cross piece such that its hole is centered over the hole drilled in the cross piece. A matching hex head bolt is threaded into the nut, so that it sits against the back of the strike plate. When this bolt is adjusted, it will adjust the position of the strike plate.

A sensor assembly is mounted on the boom arm (refer again to Figures 1 and 2). It is used to detect motion of the boom and translate it into an electrical signal that can be recorded on paper or stored in a computer. Also on the boom arm is a lead weight to make the boom act like a pendulum, and a damping assembly. The damper is needed to damp out oscillations of the pendulum in order to spread out the frequency response. Without the damping assembly, the vibrations closest to the pendulum's natural period will cause the greatest response. The frequency response is thus peaked at a specific frequency, rather than being broader.

Detail for the sensor assembly is shown in Figure 7. A plan view is shown in Figure 7A, and a side view is shown in Figure 7B. The sensor's "transducible event" results from the fact that a magnetic field moving relative to a coil of wire will induce a current in that wire. In Figure 7A, you will see a strong horseshoe magnet mounted on the boom arm of the pendulum. The magnet is fixed with a wing nut connector of the sort used to fasten chemistry and optical apparatus.

Inside the curve of the horseshoe magnet is a coil of wire. The coil should be several centimeters in diameter, and consist of about 8,000 to 12,000 turns of #36 AWG (or so) enameled wire. The former for the coil can be constructed of wood or plastic. A slow speed drill is used to scramble wind the wire onto the form.

Winding the coil can be a dangerous operation, and you take your own responsibility if you attempt it. Make sure the drill has a very slow speed (most variable speed drills will do this). Fix the drill and the form in a vise, or other fixture. The wire should be on a dowel mounted offset from the drill and form, but positioned so that it can be unwound without kinking. **WEAR PROTECTIVE SAFETY GOGGLES WHEN WINDING THE COIL.** Injury to your eyes could occur if the wire breaks, or if you do something wrong.

The mounting of the coil and magnet are shown in side view in Figure 7B. The mounting assembly can be made from either wood or plastic, or any convenient material.

The damping assembly is shown in both plan and side views in Figure 8. The lead weight is made of

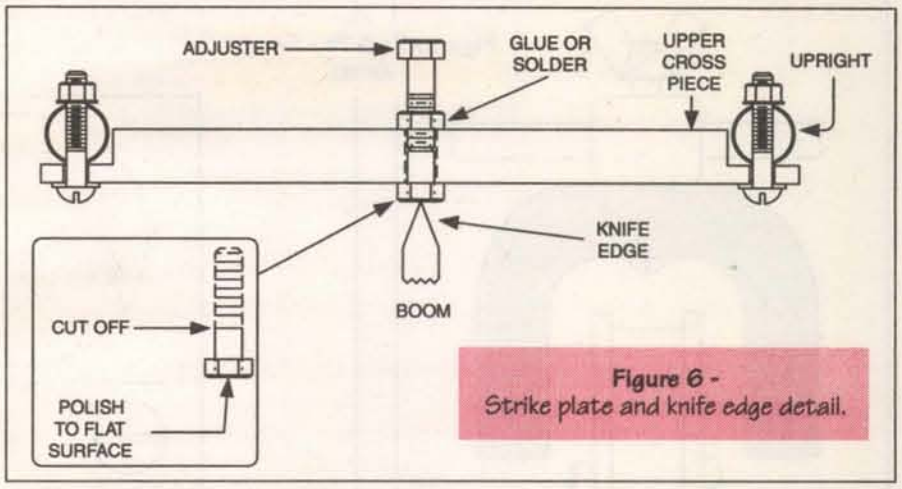
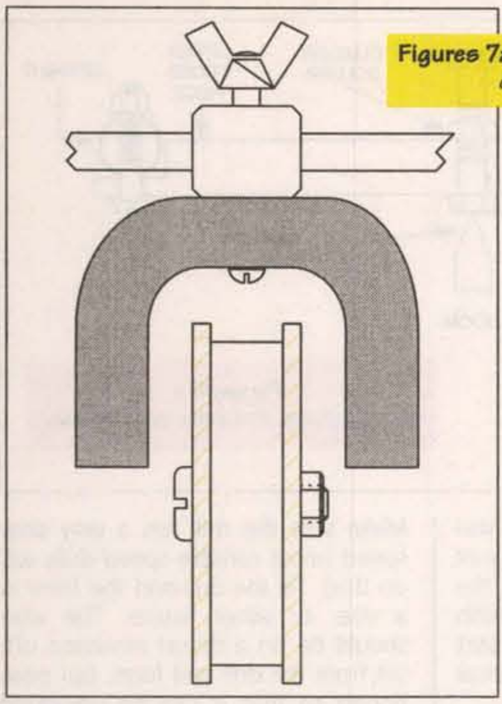
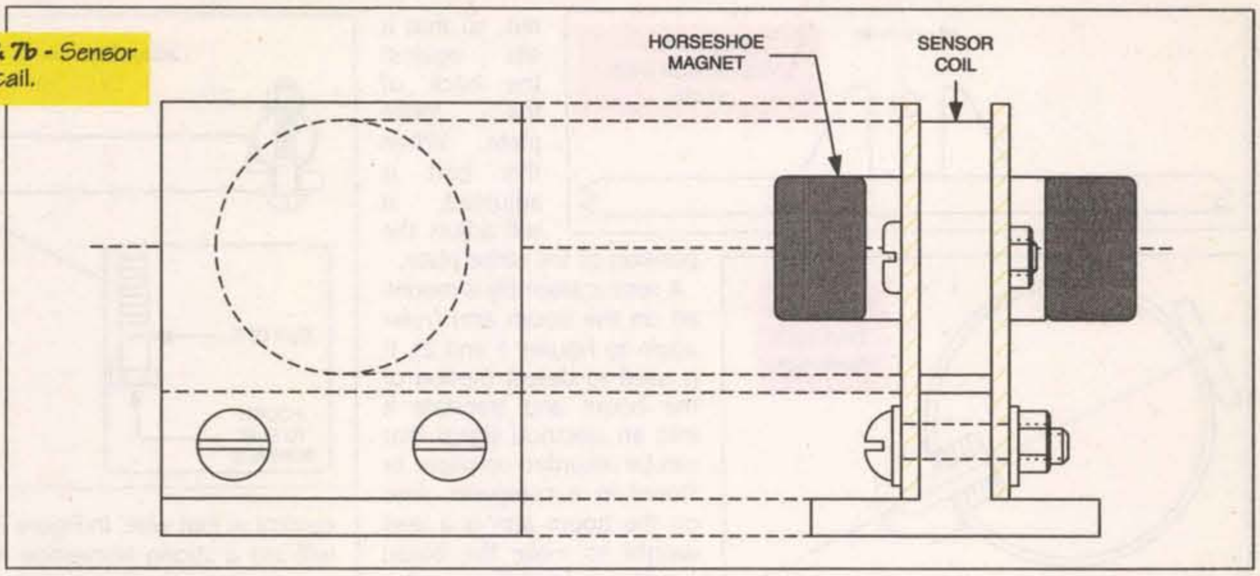


Figure 6 - Strike plate and knife edge detail.

Figures 7a & 7b - Sensor detail.

plumber's lead, and is fixed to the threaded end of the boom with a pair of hex nuts. The period of the pendulum can be adjusted by the position of the weight, if needed.

The damping action is created by swinging a metal plate through the magnetic fields of opposing horseshoe magnets. When the pendulum moves, eddy currents are set up in the aluminum plate, and these, in turn, create a magnetic field that is opposite the polarity of the field that created the current. This is a magnetic version of "rust on the door hinges" to keep it from swinging for a long time after being excited by vibration.

The aluminum plate is fixed to the pendulum by a wooden or plastic dowel. One end of the dowel is threaded to fit the thread on the eight-mm boom end. A wood screw can be used to fasten the aluminum plate to the other end of the dowel.

A variation on the damper theme is provided by Jeff Lichtman of Radio Astronomy Supplies (190 Jade Cove Drive, Roswell, GA 30075; E-Mail jmlras@juno.com and website http://nitehawk.com/rasmit/jml0.html). Jeff offers a book that he wrote on earthquake instruments. The Lehman-style seismometer that Jeff designed uses an oil bath to provide the damping function.

Seismometers are usually buried below grade. Some people place them in a simple box on a flat rock outcropping, but that is not terribly good practice. Others build a concrete pedestal and box to house the seismometer. Thermal insulation surrounding the inner chamber where the seismometer is located is used to keep the temperature stable. It is essential that the seismometer be perfectly level, and not tilted. It may take several days to get the seismometer adjusted properly.

More on Lightning ...

My column on the lightning detector raised a lot of interest, but it seems that I forgot a detail. The differential amplifier is any ordinary operational amplifier with a high input impedance. Because two are needed, a dual unit such as the CA-3240 devices are usable. Set the resistors such that the gain is about 100 to 500, depending on the sensitivity desired and the size and number of turns in the coils. The amplifiers as shown are differential, but if one side of each coil is grounded, then a single-ended amplifier can be used.

The best performance occurs when the coils are inter-twined as shown in that article. However, two coils set at right angles and close together will also serve the purpose.

The output voltage of the coil is not high tension. I had a couple people ask about high voltage amplifiers for this purpose. What you are picking up is not the HV electrical field produced by the lightning, but rather the electromagnetic wave (i.e., a radio signal!) emitted by the lightning when it strikes.

The signal sensed by the coils is the same as the static crash you hear on an AM radio when a thunderstorm approaches. In fact, an old farmer's trick for monitoring the approach of storms (including those that produce tornadoes) is to tune an AM radio to the low end of the band, between stations, and monitor for static crashes.

The shielding is used for two purposes, as on any loop antenna. First, the frequency range is very sensitive to harmonics of the 60-Hz power line (they are audible well into the medium wave portion of the HF spectrum!). But those tend to be primarily electrical fields, not magnetic. As a result, using a shielded coil will reduce the coil's sensitivity to electrical fields, while retaining its magnetic field. Make sure that a small gap is left in the shield to prevent the shield from acting as a one-turn loop in its own right.

The second reason for the shielding is that capacitive coupling to nearby conductive objects (including the ground) tends to distort the pattern of the coils. The shielding helps reduce that effect. Indeed, most professional VLF-MW receiving loops used for radio direction finding (RDF) are shielded for exactly this reason.

WWV Clocks

One of the problems faced by amateur scientists when collecting data is automatic recording of the time of day. If a computer is being used, then the internal time-of-day clock can be used. However, those clocks have a way of drifting into error over time. Recently, a number of clocks have been offered that have an internal WWV/WWVH shortwave receiver to provide correction. One clever soul wrote to me via E-Mail (see "Connections..." below) and told me that he had found one model that had the Binary Coded Decimal (BCD) data line easily available ... and used it for time recording. Clever dude! **NV**

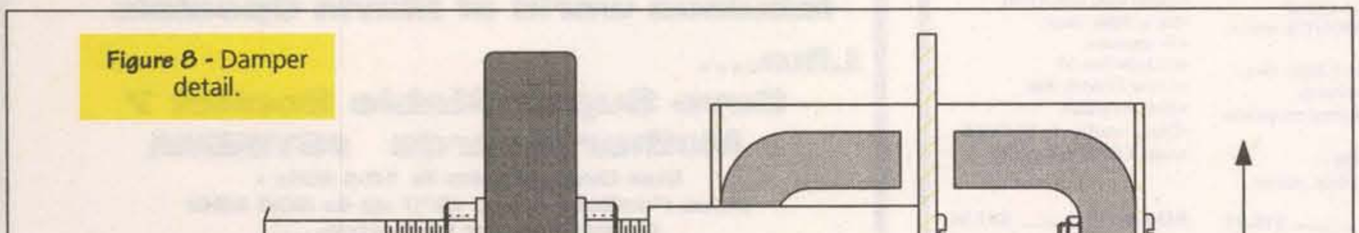


Figure 8 - Damper detail.

Connections ...

I can be reached by snail mail at P.O. Box 1099, Falls Church, VA 22041, or via E-Mail at CARRJJ@AOL.COM.

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Reno 89511

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Belmar 07719

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New York 10023

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New York 10003

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Wadsworth 44281

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Mentor 44060

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Toledo 43613

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Steubenville 43952

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Toledo 43604

Powermaxx, Inc.
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Xenia 45385

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Tulsa 74114

Taylor News & Books
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Oklahoma City 73102

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Medford 97501

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259-C Barnett Rd.
Medford 97501

Norvac Electronics
7940 S.W. Nimbus Ave. Bldg. 8
Beaverton 97005

960 Conger
Eugene 97402

1545 N. Commercial N.E.
Salem 97303

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33 N.W. Park
Portland 97209

Tower Books
1307 N.E. 102nd Ave.
Portland 97220

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Nashville 37203

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Houston 77002

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Houston 77063

Mouser Electronics
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Mansfield 76063

Tanner Electronics
1301 W. Beltline #105
Carrollton 75006

Tower Records
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Austin 78705

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Richmond 23220

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Fairfax 22033

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Morton 98356

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Seattle 98109

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Amateur Electronic Supply, Inc.
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Milwaukee 53223

Greenfield News & Hobby
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Greenfield 53220

Cudahy News & Hobby Ctr.
4758 Packard Ave.
Cudahy 53110

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Western Test Systems
2701 Westland Ct. #B
Cheyenne 82001

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ELECTRONICS Q & A

With TJ Byers

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.
Feel free to participate with your questions, as well as comments and suggestions.
You can reach me at:
TJBYERS@aol.com
TJBYERS@juno.com
or by snail mail at
Nuts & Volts Magazine,
430 Princeland Ct.,
Corona, CA 91719.

What's Up:

Servos, steppers, and flying ships (blimps). An exciting web site for monitor specs and pinouts. Some robotics stuff, and how to interface Motorola's GSPD receiver to the 'bot.

Finally, a free cure for the I-Worm.ExploreZip virus,

PC RAM explained

and good feedback from our readers.

Lighter Than Air

Q. I'm trying to build a twin-engine electric motor R/C blimp. The biggest problem I'm having is that I'm not familiar with the way radio receivers and servos work. I need a way to control the speed of both motors using one channel for total throttle and another channel to slow one or the other down so that it will turn and, if possible, reverse as well. Do you have any thoughts or comments?

Michael Black
via Internet

A. I'm not all that involved with RC myself (my last RC plane mysteriously flew off to the wild blue yonder, never to be seen again; out of radio range, I'm sure, or jammed by another), but I can give you some pointers. For instance, there are two schools of thought on how to control a blimp. The first uses a rudder and elevators (horizontal fins) to control the airship's movement. There are two widely-separated stepper motors that are synchronized like the motors of a twin-engine propeller plane. To steer the blimp, you use a servo motor to move the rudder left or right, and another servo to move the elevators up or down. Three channels are needed: one for the throttle, one for the rudder, and one for the elevators. The other school of thought is to throttle the motors to steer the airship. This, too, uses three channels to steer the ship: two for the motor throttles (maybe it can be done using one channel to throttle a single engine, but then you'd only have one speed — full ahead) and one for a servo that sets the angle of the prop to move the blimp up or down. According to the experts, either is easily accomplished using off-the-shelf RC equipment that you can find at most hobby shops. You can also buy blimp kits, assembled blimps, and specialty parts from the larger hobby outlets. For more information on blimps, check out the following web sites.

West Coast Blimps & Electronics
760-375-2108
http://www1.ridgecrest.ca.us/~jpiri/

Fil's RC Page
http://www.repairfaq.org/filipg/RC/Fils_RC.html

Remote Controlled Flying Saucer/Blimp
http://www.link.ca/saucer

High-Torque Servos For Robotics

Q. I met the creator of the "Ninja Turtles" at the show biz expo several years ago. He said the turtle's heads were all "D" type servos. I've always wanted a real torque-producing servo at a decent price for larger robotics. If you have some info on this, I'd be interested. In fact, I'm sure a lot of robotics folks would like to do more than move a small device via servo!

Walt Noon
via Internet

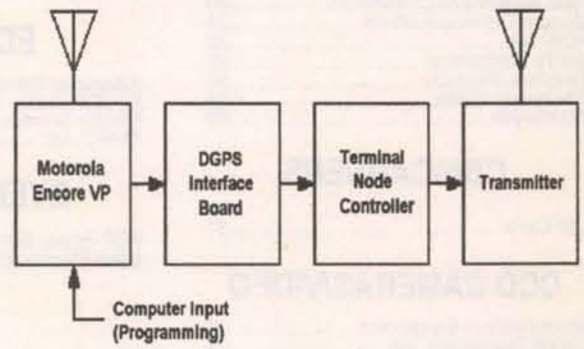
A. The largest pulse-actuated servo (the RC variety) I can find is the **FMA Direct (1-800-343-2934; http://fmadirect.com/pages/servo.htm)** S500. It has a torque of 298 oz./in., which translates to a whopping 18 pounds/in., with a fast response time of 0.20 seconds. Best of all, it sells for a low $44.95. Hitec has a 224 oz./in. servo (model HS-805BB) which sells for about $48.49. Airtronics also makes servos in this torque range, but they sell for a lot more unless you can find them surplus from outlets like **Alltronics (408-943-9773; http://www.alltronics.com)**. To get more torque than this, you need a stepper motor with a gearhead and optical encoder. Check out the companion feature article "Servos, Steppers, and Optical Encoders" on page 84 for more information.

Initializing Motorola's Encore VP GPS Receiver

Q. I recently read an article that described a system using a GPS satellite to obtain a very accurate reference frequency that can be used to calibrate quartz frequency standards and plot a forecast of their aging. The article was written by some very smart guys who are familiar with the theory and construction of the various equipment needed. I, on the other hand, got lost when trying to control the Motorola GPS receiver, which is programmed via the RS-232 port of a computer. I don't get it. How can I use this port for both input and output the GPS and the interface card require? I'm not even clear as to whether one or two ports are needed. I thought reading up on this serial port might shed light on the subject, but I cannot find your previous comments on the RS-232. What can you tell me?

W.R. Risk
via Internet

A. The system you describe is what's called DGPS, Differential Global Positioning System. The system was originally devised to correct for the dithering of the onboard atomic clock (to prevent enemy forces from using it to guide their weapons), and it's often used by ham radio operators for a variety of applications — including a frequency reference. Here's a block diagram of the system.



The Motorola Encore VP receives the signal from the satellite and sends it to an interface board, where the various data bytes are decoded and presented in a format that is recognized by other equipment. Often the processed signal is rebroadcast over the ham bands, typically two meters (144.39 MHz). However, the Encore VP won't do anything until commanded. Here's where the PC comes in. The PC sends setup commands (you can find the setup software on the Internet at http://www.tapr.org/tapr/html/Ftac32.html) to the Encore VP through its RS-232 serial port. The PC supports four serial ports, COM1 through COM4, any of which can be used to setup the receiver. If all your serial ports are in use, temporarily disconnect one of the devices while you setup the receiver. Once setup, the receiver can be removed from the PC — unless power is lost, in which case, you may have to initialize the receiver again. (Motorola sells a back-up battery option that saves the setup if power is lost.) Read the next question for more details on this receiver.

It's Telex, Not TV

Q. I know you have a good source of pinout information, so I'm hoping you can help me with a real dinosaur. The pinout I need is for an old Telex 10-inch monitor which was manufactured way

back in Feb. 1985 according to the label. The model number is 207243-002. When it's turned on, the screen glows amber, but that's it. There's a rotary control behind the front lip, which doesn't seem to do anything. It has a nine-pin female D connector on the bottom only marked as "20."

I was also wondering if there's a fairly simple way to convert an old IBM CGA monitor for use as a color monitor for a VCR using the RCA output jack? I have several on hand and would hate to see them go to waste.

Gary DePietro
gary.depietro@dlbbs.com

A. It's a Telex display screen, not a computer monitor. Prior to the Internet, International business was conducted almost exclusive over dedicated Telex lines (and still is, to a large extent) because it's a secure link with a hard copy at both ends that's totally in sync — character by character. That way each party sees what the other sees as it happens, making it virtually impossible to alter the document. There are two types of telex terminal equipment that can be used for international telex service. One is KDD subscriber terminals, and the other is NTT subscriber terminals. For KDD subscribers, a direct tie-line contract is made between the customer and KDD. The NTT subscribers can also utilize international telex service by making a switched access contract with KDD. International telex service is also available using public telex terminals at KDD offices, and through telephone lines by using personal computers and other terminal equipment.

As for using a CGA monitor with your VCR, it's not practical. The VCR signal is analog with composite sync and the CGA monitor is digital with separate horizontal and vertical syncs. Such a converter would require a sync separator and three A/D 8-bit converters. It's easier to go from CGA to VCR video using an RGB-to-video converter, rather than the other way 'round.

All About Conductivity Probes

Q. I'm an avid electronics hobbyist who can't get enough of my hobby, which is why it's my career as well. I do a lot of control and instrumentation work at my job, and one of the instruments is a simple conductivity cell. It measures the conductivity of regular tap-water, and provides a reading in microsiemens (uS).

Anyway, my probe and meter are currently out of commission, and in the fix-it shop. What I'd like to know is the standard setup for measuring water conductivity (meaning probe construction or arrangement), as well as the electrical parameters involved. Clearly, merely sticking the probes of a DMM into a sample bottle does NOT work — I tried it.

I've also tried a regulated 12-volt DC power supply across a pair of electrodes in series with an ammeter. I got a result that's in the neighborhood of 500 uS/cm, but the readings change too much from sample to sample to be reliable. Also, the probes have a tendency to form an electrolytic cell, which doesn't happen in a regular conductivity probe. Any information you could provide would be greatly appreciated.

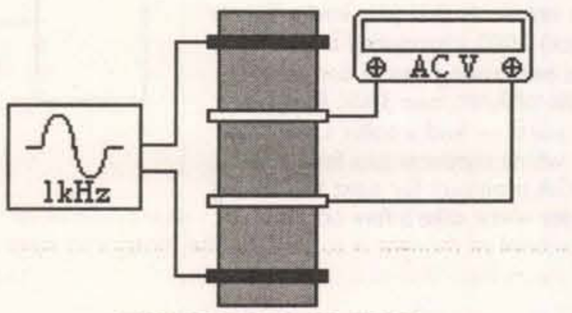
Michael J. Gordon
Operations Engineer
NHMFL Long Pulse Magnet Facility

A. A solubridge, or conductivity meter, measures the conductivity of a liquid. Conductivity is the reciprocal of resistance — that is it expresses the liquids ability to pass current as opposed to limiting it, as resistance does. Conductivity is expressed in millisiemens (mS) or microsiemens (μS) per centimeter. If a liquid cylinder with length 'L' and cross section 'A' has a conductance of 'G' Siemens, the conductivity 'S' is equal to

$$S = G \times L/A\ (\mathrm{S \cdot cm/cm^2}) = G \times C\ (\mathrm{S/cm^2})$$

It's extremely difficult to accurately measure conductivity using conventional amperometric probes because of the polarization effect you noted. The most common solution (no pun intended) is to use an AC voltage to measure the conductivity of the water, but it doesn't completely eliminate it. To try to get around the problem of polarization, different probes are sold, each with a different cell constant. Conductivity sensors are available in a variety of cell constants, typically 0.01, 0.1, 1.0, and 10. Cell constants are matched to the meter or controller for the expected range of operation. The different cell constants act like mechanical multipliers for the solution's resistance. By using different cell constants, the same meter or controller can operate over the same resistance range for both very low conductivity solutions (like ultra-pure water) and high conductivity solutions (like sea water). Unfortunately, this requires frequent probe changes coupled with a time consuming calibration for each probe change. Moreover, the results depend on factors that can't be completely controlled. Temperature, for example, is of great importance; conductivity increases with temperature at the rate of approximately 2% per degree C. That's why most conductivity probes are temperature compensated, which increases their cost.

Recently, I ran across a unique conductivity cell from **Hanna (http://www.hannainst.co.uk/conductivity.html)** that's every bit reminiscent of a low-resistance milliohmmeter using a four-wire Kelvin circuit.



POTENTIOMETRIC SOLUBRIDGE

Like a Kelvin bridge, the four-ring Hanna sensor probe is a potentiometric system which overcomes the problems encountered with amperometric probes. The meter applies an alternating voltage across the top and bottom rings. When the probe is immersed in a liquid, the current flow from ring 1 to ring 4 produces a voltage across inner rings 2 and 3. This current is amplified and a calculation is performed to give the conductivity of the liquid.

Don't Zap That Short

Q. I have a number of circuit boards of various types that all have shorted components. In the old days, we'd just clip off the 0.1uF caps until the short was cleared, but you can't do that with chip caps. Is there a way to "blast" these with a low-voltage, high current without damaging the ICs and other parts? I was thinking that a high-current, 5-volt power supply would do the trick.

Jeff Kerner
via Internet

A. Sure, I can give you a circuit that will blast these shorts. The problem is that it will blast the PC board traces, too. Many years ago, I bought a boxcar lot of defective AM/FM clock radios which had mostly shorted AGC electrolytic capacitors. Once I found the defective part, it was easy to rip out and replace ONE capacitor, and make a tidy profit for myself by selling the fixed units back to the manufacturer. Your problem is more complicated in that the 0.1uF capacitor is plentiful on the boards — and more than one is likely to be bad. This is just a suggestion, but I think you could apply

a lower voltage, something along the lines of 3 volts as opposed to the 5 volts that normally power the circuit, and let your fingers do the walking — walking across the bypass capacitors, that is, looking for one that's too hot to handle. That'll be a shorted one. Rather than cut it out, I'd replace it using the SMD method I described in the Apr. '99 issue (page 9). The cap is really needed. Unfortunately, this method isn't foolproof, because a dead short will be ice cold. Do like I did and check out the markings on the defective parts you do find. Chances are they came from the same lot, and all are likely to be bad. Good luck!

A Monitor It's Not ... But The Web Site Is Hot

Q. I have noticed that you get quite a few requests for information on specific monitor types and their connector pinouts. I found a wonderful resource for information of this type. It is: **http://www.monitorworld.com.** Although I have used this web site to find the pinouts for many different monitors, they have no information on a Sperry Model Number 3617-00 display, which I'm now the proud owner of two. There's a six-pin DIN connector on the back labeled simply Signal In. At first, I thought that these were some sort of data terminal — however, they are classified as an FCC type B device, which leads me to think they were manufactured for household use. I believe they are monochrome units and pretty much useless — but I'd like to connect them to my even more ancient RadioShack TS-1000, if possible. I know this is stretching it, but I hate to throw things away unless absolutely necessary.

Robert Turner
via Internet

A. Hey, thanks a lot for the http://www.monitorworld.com web site. I'm sure it'll help our readers a lot. Now about your "monitors," you can toss them because you guessed right. They are terminals that plug into a Sperry (now Univac) mainframe. The Tandy (RadioShack) 1000, introduced in 1984, is a nearly 100% IBM compatible, which became its best selling line of computers ever. It came with an Intel 8088 processor, 640K of RAM, two 360K floppies, plus a good assortment of serial/parallel/game ports — and a color CGA output. CGA you ask? It's IBMs first stab at color which supports just four colors and 200 by 400 resolution. You can still find CGA monitors for next to nothing by shopping hamfests and computer flea markets — or take a few off the hands of our next reader.

All About PC RAM

Q. I upgraded the memory in my laptop and would like to reuse the old modules in my desktop. I've been trying to get one of those memory converter cards that change one pin type to another, but so far, the only cards I've found are for the 30-pin and 72-pin variety. The old memory modules from my laptop are smaller and have 144 pins. Would you please help me in locating a 144-pin to 72-pin version?

Luis Garcia
via Internet

A. Bad news, they don't make them. I recently upgraded from a Pentium 200 to a Pentium II, and now have a drawer-full of 72-pin SIMMs I can't use. Must be planned obsolescence. Anyway, you're fortunate that your left-over memory is 144-pin, which can be used in any number of notebook PCs — but never in your desktop. In other words, don't throw them away. You can always sell them. Curious about the types of PC memory out there, and where it fits? Here it is.

Memory Type	Number of Pins	Bus Width	Application
SIMM	30	8 bits	286/386
SIMM	72	32 bits	486/Pentium I
SO DIMM	144	32 bits	Pentium II laptop
DIMM	168	64 bits	Pentium II desktop

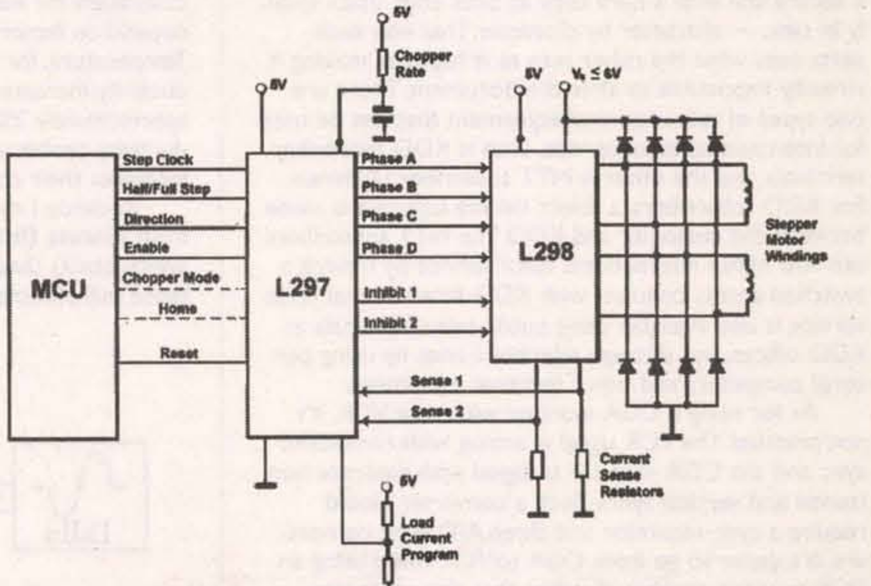
SIMM stands for single in-line memory module, which means the pins on both sides of the plug-in module are duplicated. Whether you connect to the left or right side, it's the same pin. DIMM stands for dual in-line memory module, where the fingers on opposite sides of the PC board have a different contact. SO DIMM is a small outline DIMM primarly used for notebooks. Now I suppose you want to know about memory speed. Memory modules have speeds that range from 70 nS to 10 nS. Check your PC's manual to see which speed your PC needs. As a rule, the faster the CPU clock, the faster the memory module. And there's no such thing as having too much speed, but too little speed can hang up the system. The tradeoff is that the faster the memory, the more the cost — so it's smart to match the CPU speed to the memory speed, as your manual points out.

Stepper Motor Driver Needed

Q. I want to drive an AIRPAX bipolar stepper motor (rated 5 volt, 1.0 amp) from a PIC 16F84. I have seen chips for stepper control, but they only have 300 mA to 500 mA of current capability. Do you know of a stepper controller chip capable of driving the AIRPAX directly? I'd love to get this going so I can make a computer-controlled milling machine using my Shopsmith or my cross-slide and a Dremel tool.

Jerry Rutherford
via Internet

A. There are several choices, as you'll discover from the companion article "Servos, Steppers, and Optical Encoders" on page 84, but for this particular application I'd use an L297 controller coupled with an L298 driver — both made by ST Semiconductors. Both chips are available from **Mouser Electronics (1-800-346-6873; http://www.mouser.com/).** About $10.00 with shipping (Mouser Electronics doesn't have a minimum). Here's how to wire them together.

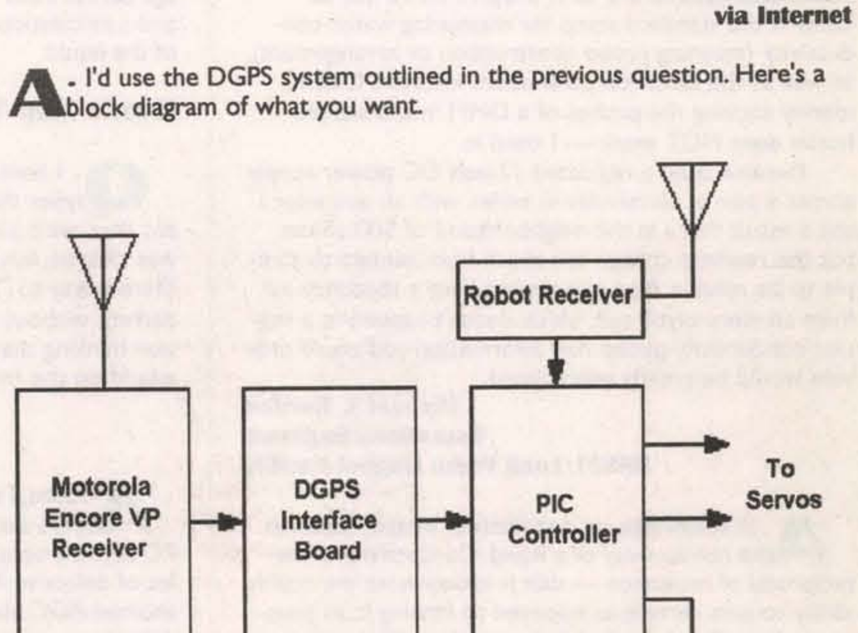


GPS-Guided Robot

Q. I would like to build a mobile robot which utilizes GPS for navigation. Can you point me in the direction of a low-cost GPS receiver which I can use? I will be using a commercially available single-board computer (SBC) as the "brains" for the vehicle. Therefore, I must have detailed protocol specs for the receiver which describe how to initialize and communicate with the device via the SBC.

K.A. Delahoussaye
via Internet

A. I'd use the DGPS system outlined in the previous question. Here's a block diagram of what you want.



The receiver is a Motorola Encore VP ($290.00), a PC board that measures

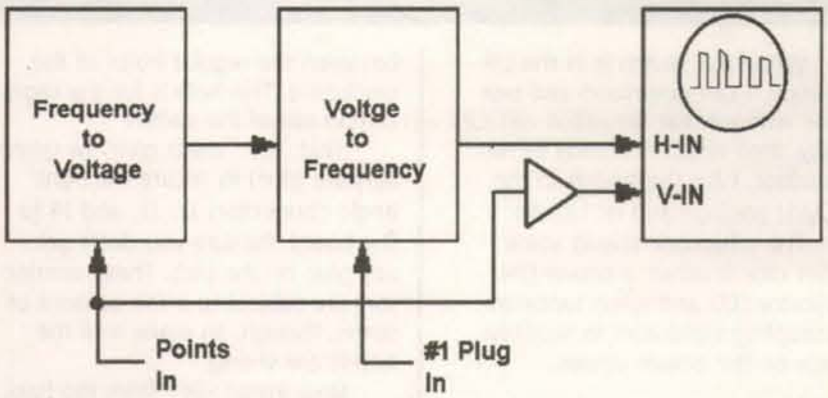
2 by 3 1/2 by 1/2 inches, and the decoder is the TAPR Digital GPS Reference Satation Interface Board ($199.00); both are available from **Tucson Amateur Packet Radio (940-383-0000; http://www.tapr.org/gps/).** The output from the interface board is in the widely recognized RTCM SC-104 Type I Version 2.1 message format. The output is at RS-232 levels and can be processed by any device capable of receiving RS-232 serial data, like your SBC or, better yet, a PIC or Stamp chip. As before, the GPS receiver has to be programmed before use via an external PC. If you don't provide the optional battery backup, the programming will be lost when the power to the 'bot is turned off — well, kind of. Actually, the only thing lost is the almanac, which is a history of the satellites and their position. The receiver itself will re-acquire this information when power is reapplied, but it can take hours and not to the same degree of accuracy as the PC's initializing routine. So opt for the battery backup. For more details on putting this package together, check out the TAPR web site listed above.

Auto Tune-Up

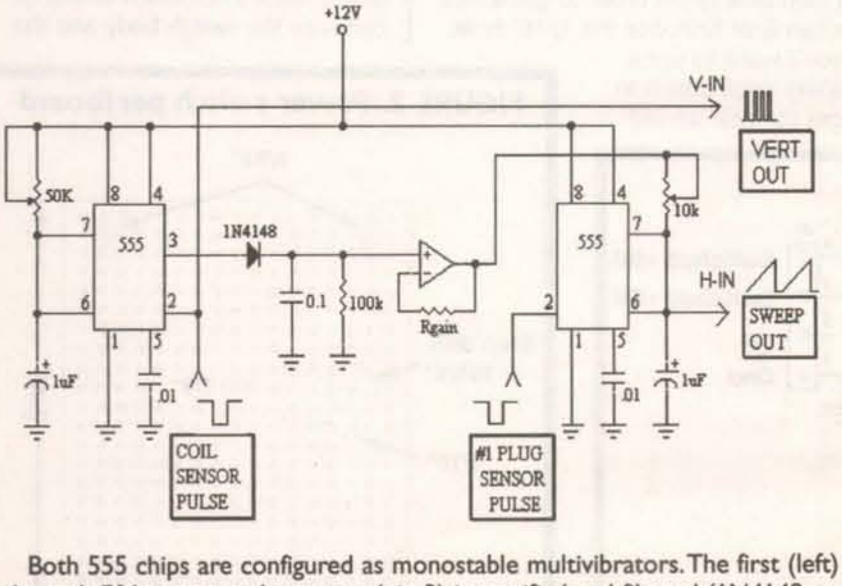
Q. On automotive engine analyzers, there's a display that shows spark plug voltage on the y axis and time on the x axis. As the engine speed varies, so does the sweep rate of the x axis so that all eight spark plugs appear in a fixed position on the screen regardless of the engine RPM. If the sweep rate were fixed, the spark line would expand and contract as the engine speed changed. I need help designing a sweep circuit that keeps pace with the engine speed. I'll be using an inductive pickup to sense the ignition voltage.

Mike
via Internet

A. What you need is a tachometer to monitor the engine RPM and a circuit that converts this value into a tracking sawtooth waveform. For the tach, I'd use a frequency-to-voltage converter, then use its output to drive a voltage-controlled oscillator. Here's a block diagram.



Notice that the output of the new sweep generator replaces the internal sweep circuit of the oscilloscope, and plugs into the external horizontal input. This oscillator is triggered off the #1 spark plug sensor. The tach output voltage is generated from the signal derived from the wire that goes from the high-voltage coil to the top of the distributor cap, which is also fed to the vertical (y axis) input. Neither circuit is critical, and can be made using 555 chips.



Both 555 chips are configured as monostable multivibrators. The first (left) is the tach F/V converter. Its output (pin 3) is rectified and filtered (1N4148, et al), then buffered by an op amp. The gain of the op amp is set by Rgain, which changes according to the op amp you select (check out the National Semiconductor CLC series). The resultant output voltage charges the timing

Continued on page 83

AMATEUR ROBOTICS NOTEBOOK

by Robert Nansel

Chaos rules the Robot Ranch during the dog days of summer.

As I write, it is 95 degrees and muggy as all get out in Pittsburgh. We have one room that's air-conditioned (barely), so my brain hasn't boiled away, at least not yet. I've been working on the code for Breadbot's quadrature encoders, as well as the substantially more complicated I2C code for interprocessor communications for last month's multiprocessor DT111.

My hope is to get all this working on plain old 10MHz PIC16F84s, but I am finding the project to be very challenging, even without the heat to muddle my thought processes. Then, too, I'm in the middle of a major changeover in computer and OS (more on that later), and my six-month old son is teething. Did I mention that it's hot?

Anyway, when I get frustrated with slow progress on software — especially when it's 95 degrees — I retire to my basement workshop where it's cool, and I drill holes in things for a while. Though the code I promised last month isn't ready yet, the hole drilling did do some good: Breadbot now has a power switch board.

Civilizing Breadbot

For more than a year, I've been directly plugging the +6V wire from the battery pack into Breadbot's breadboard. To turn Breadbot off, I've had to either remove the AA cells or yank the power wire. The wire is stranded wire and tinned, so all this plugging and unplugging takes its toll, both on the breadboard and on the wire. Thoroughly uncivilized.

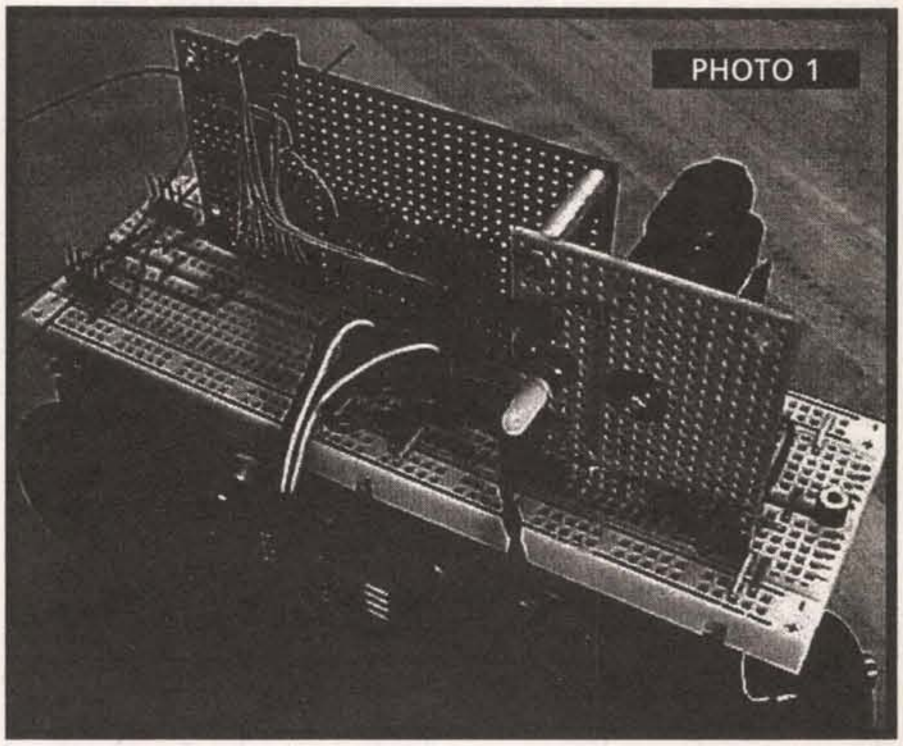
When I first built Breadbot, I looked around for a power switch I could plug into the breadboard, but I never found anything satisfactory. For Breadbot's latest brain transplant, I decided I should figure a way to add the switch, perhaps using the prototyping section of the DT111 where there would be plenty of room.

Not long after I installed the DT111, though, I discovered that it tended to be a bit wobbly plugged into the breadboard because it's twice the height of previous SIMMSticks I've used. The idea of adding still more mass to an already wobbly board no longer appealed to me, so I searched for another way.

While I was at it, I wanted to separate the servo power supply from the logic supply. Adding a 9V battery to power the logic is the way Parallax's GrowBot works, but where to put the battery on Breadbot?

The solution is shown in the photos and Figures 1 through 3. The board provides a place to mount the power switch and the 9V battery holder, and a mounting hole and spacer connect it rigidly to the DT111 so that neither board wobbles.

It's an easy circuit to build on perfboard. In Figure 1, SW1 is a three-position DPDT toggle switch, center position OFF. I wired SW1 so unregulated logic power from the 9V battery is applied in both of the ON positions, but the 6V servo motor supply is on only in the DOWN position.



When the switch is in the UP position, I can download and test code without fear Breadbot will run away, then when I'm ready to run Breadbot, I flip the switch to the DOWN position and let her rip.

The schematic shows some other nice touches: a power-ON indicator LED and some tantalum decoupling capacitors to suppress noise on the power busses.

Building the Board

Cut a piece of standard perfboard to the size shown in Figure 2 and drill the holes as shown. The 1/4" hole may require drilling one or two smaller intermediate holes ("step drilling") in order to get a nice clean final hole. For the 1/16" hole, you'll want to use a sharp prick punch to get the drill started between the regular holes of the perfboard. This hole is for the registration tab of the switch.

Next, use "super glue" (a cyanoacrylate glue) to secure the right angle connectors J2, J3, and J4 to the board. Be sure you don't get any glue on the pins. These connectors are subject to a fair amount of stress, though, so make sure the bonds are strong.

Now install SW1 from the back side as shown in Figure 3. Orient the registration tab so it fits into the 1/16" hole beneath the 1/4" hole and tighten the hex nut on the front side of the board.

Next, test-fit the battery clip with an 1/8" pop rivet to hold it in place. There's not much clearance between the switch body and the

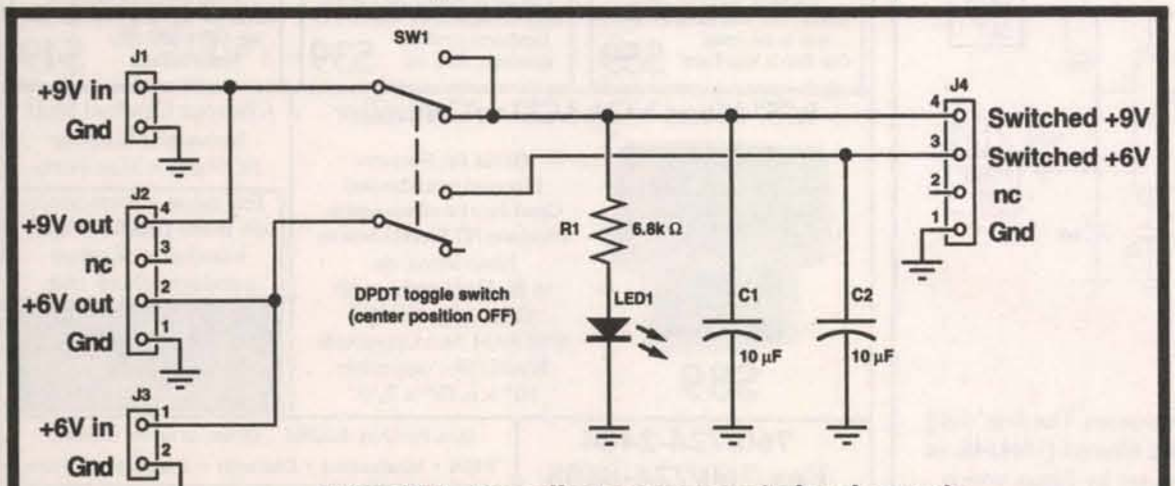
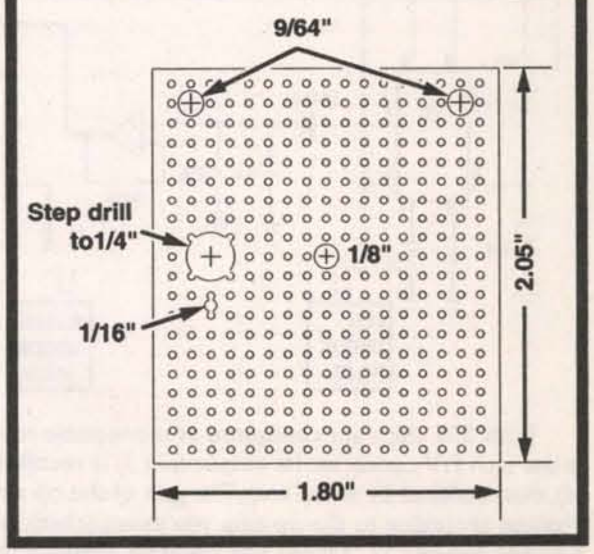


FIGURE 1. Breadbot power switch schematic

FIGURE 2. Power switch perfboard



clip, so make sure the clip won't be exerting any pressure on the switch when the 9V battery is in place.

Roughen the underside of the metal clip with sand paper to give more "tooth" for the glue to grab onto. Apply the glue to the clip, slip it and the pop rivet back into place on the back side of the board, add a riveting washer on the front side, and rivet the holder clip to the board. Be careful of orientation because you might not get a second chance with the glue. The rivet is to hold the clip securely to the board and the glue is to keep the clip from turning.

Place the remaining components, R1, LED1, C1, and C2, as shown and bend their leads to hold them in place while wiring. I did all ground connections first with 24 gauge bare bus wire on the front side of the board. I refer to this kind of construction as wire "stapling" or "stitching" because the ends of each bus wire run are bent at right angles (like a staple) and fed through the board to make the connections on the back side of the board.

I used needle-nose pliers to tightly form the wire ends around the connector pins and against the board to provide extra mechanical strength for the connectors.

The capacitors are wired directly between ground and their respective switched voltage output pins on J4. R1 and the anode of LED1 are connected together just by bending their leads parallel to each other and flat to the board. The cathode of LED1 is connected to another run of bare bus wire that ties into the main ground bus. Solder, then trim leads.

It's a Snap

The rest of the wiring is accomplished in three steps. First, wire the leads of J1 – a 9V battery snap-on connector – to the corresponding pins of J2. The twisted leads of J1 can be dressed to fit between the metal battery clip and SW1, though you may have to temporarily loosen the hex nut holding the switch so the switch can move enough to allow the wires to slip into place.

Second, make the connections to the switch. For the switch specified, the two center row solder lugs are the poles of the DPDT switch, and the upper and lower row lugs – four in all – are the "throws" or contacts of the switch with the lugs lining up in a column representing one half of the switch.

If you use a different switch, then check with an ohmmeter to find out the proper arrangement of the contacts. The 6V and 9V power inputs are wired to the center lugs, and the switched outputs are taken off the upper and lower row lugs.

Third, wire the switched contacts to their respective switched 9V and 6V outputs on J4. The 9V side of the switch has both switched contacts wired together so 9V is ON in either switch position, while only the upper lug of the 6V side is connected so servo power is ON only when the switch is in the DOWN position.

The switch board plugs into Breadbot as shown with a 0.8" long by 1/4" diameter 4-40 threaded aluminum spacer to join it to the DT111. I cut my spacer from a longer spacer and filed it to size. In the photos it may appear that the top edges of the switch board and the DT111 aren't parallel as seen from the side. This is because the solderless breadboard chassis of Breadbot itself is curved. It's easy to compensate for this so the mounting holes line up with each other by adjusting how deep you plug J2 into the breadboard.

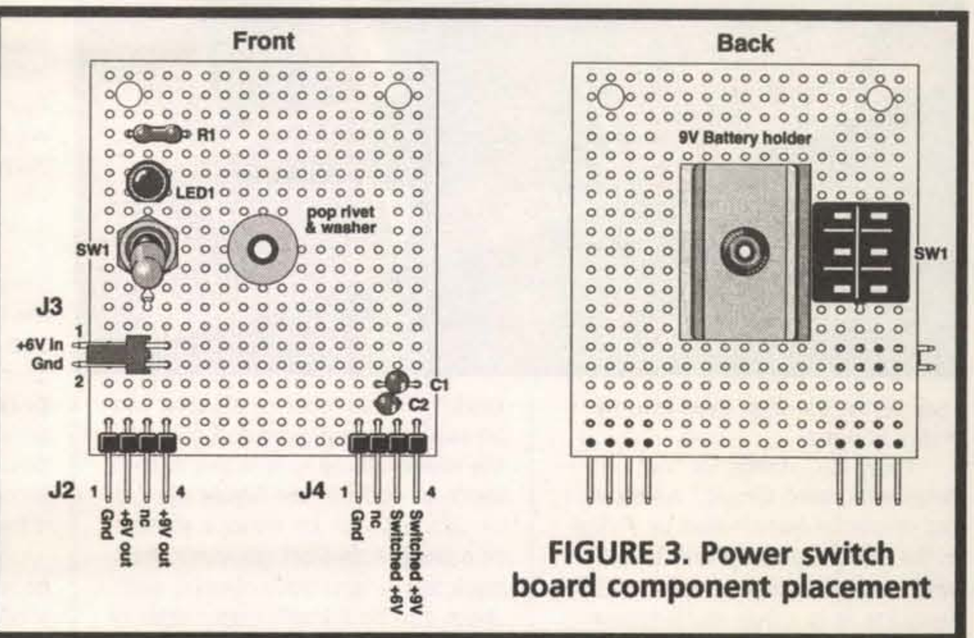


FIGURE 3. Power switch board component placement

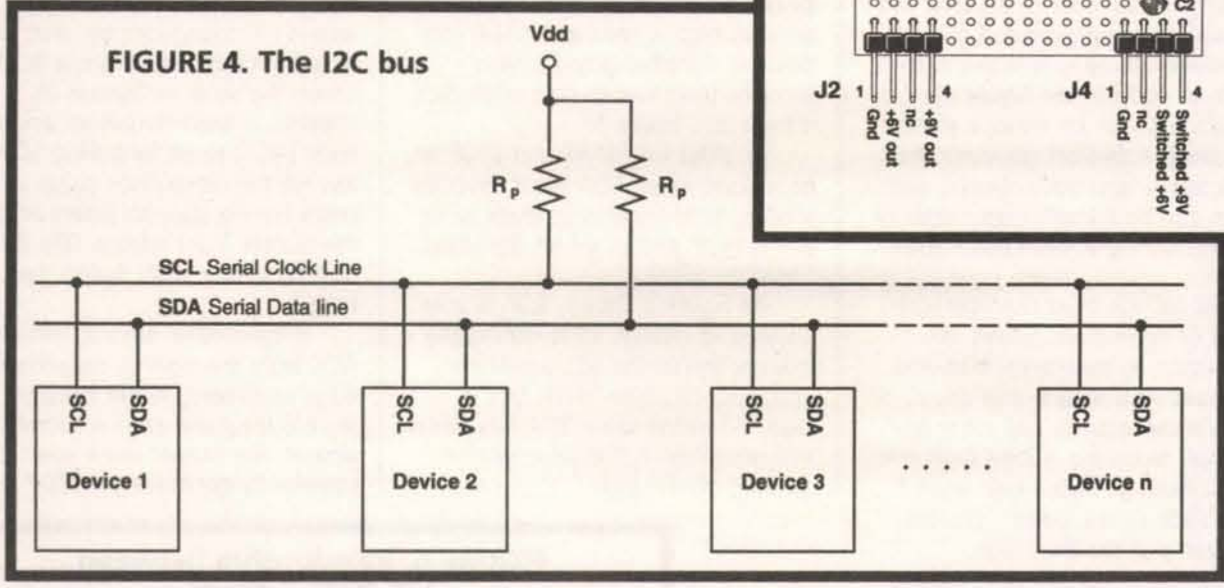


FIGURE 4. The I2C bus

Eye-Squared-See?

Last month, I gave a very brief overview of the I2C system. This time and next I aim to give a full introduction but, for the whole story, you'll need to consult various data manuals and appnotes from Philips Semiconductor.

If you find discrepancies between what Philips says and what

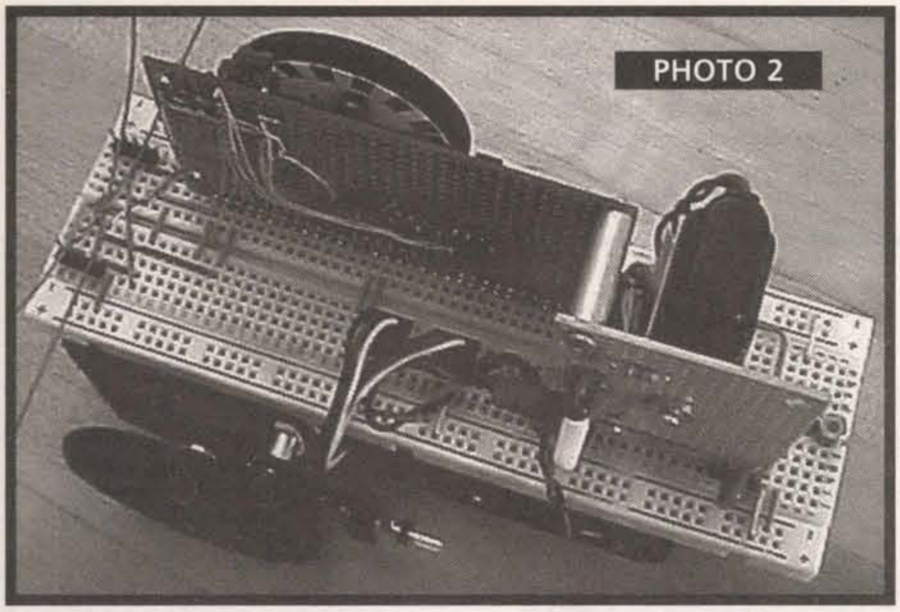


PHOTO 2

I say about the bus, then assume Philips is right.

Okay, I2C stands for "IIC" or "Inter-Integrated Circuit," a simple but powerful bus created by Philips in the 80s as a cheap way to network ICs in consumer electronics products. It is a true multi-master synchronous serial bus. It has collision detection and automatic arbitration to prevent data corruption should two or more masters attempt to transmit on the bus at the same time.

Only two lines are required, SCL (Serial Clock) and SDA (Serial Data). Bidirectional transfers can be made at up to 100 kbps in standard mode and up to 400 kbps in fast mode (I'll be talking only about standard mode). The number of ICs that can be so networked is limited only by the maximum allowable bus capacitance of 400 pF (see Figure 4).

Each IC can be either a master or a slave – masters generate the clock SCL – and both masters and slaves can be either a transmitter or receiver during a given bus transaction.

All I2C ICs must use open-collector or open-drain drivers, or equivalent, to drive both SDA and SCL lines. This means that any IC on the bus can actively pull these lines low but, to output a logic high level, the IC must go into a high-impedance state so the pullup resistors (Rp) can pull the lines high.

SDA and SCL are both bidirectional, so each IC's data inputs are connected to the open-drain outputs. Thus, when an I2C IC reads the status of SDA or SCL, the level read reflects the status of the bus.

If the IC is outputting a logic low, then that's what the input will see, but if the IC is outputting a logic high, then the input will only see a high level if no other IC is asserting a logic low. This is the equivalent of an AND gate; the line will be high only if all the ICs are outputting logic high. Hence, this is often called a "wired AND" configuration.

To signal the beginning of a bus transaction, an IC must first wait for the bus idle state where both SDA and SCL are high for at least 4.7 usec. The IC can then signal START by bringing SDA low while SCL remains high. Likewise, a STOP condition is signalled when SDA is brought from low to high while SCL is high (see Figure 5).

In order for START and STOP to be unique, then, SDA must never be allowed to change logic levels while SCL is high, except when signalling START or STOP.

As Figure 6 shows, SDA is only allowed to change state during the low portion of the SCL waveform and must be stable while SCL is high. Whatever value SDA has when SCL goes high is the value of that data bit on the bus.

Ack! A Datagram!

Any number of bytes can be transmitted or received in one datagram, but the simplest possible I2C bus datagram comes when a master reads or writes a single byte to or from a slave. In Figure 7, the top two waveforms in the figure are the data from the master and slave, respectively, that drive SDA, and the SDA waveform below them is the composite of the two open-drain data sources. The master addresses the slave (binary address 0111000), then reads the binary data 0110101 from the slave.

The transaction goes like this: First, the master generates the START condition then acts as a transmitter to send the seven-bit address of the slave. The eighth bit sent is the read/write bit, and the logic high indicates this is a READ. When the slave recognizes its address, it must output an acknowledge (ACK) pulse by pulling SDA low for the ninth clock pulse. In order for the slave to assert ACK, the master must release SDA by outputting a logic high during that time.

If the master doesn't receive an ACK from the slave (a no acknowledge condition), either because the slave is busy and can't respond or is absent, the master must abort the transfer by generating a STOP

FIGURE 5. I2C START and STOP conditions

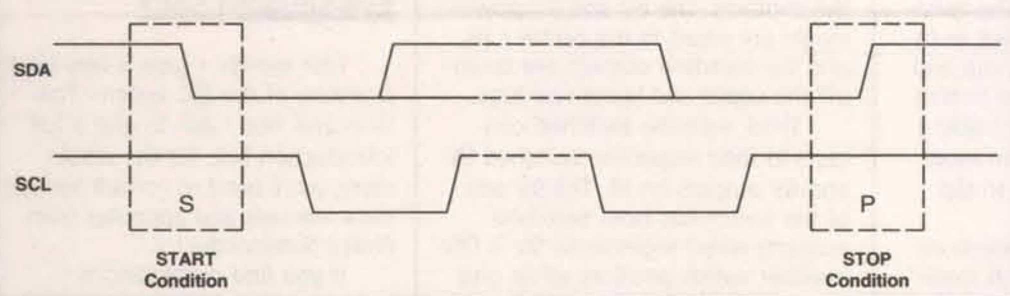
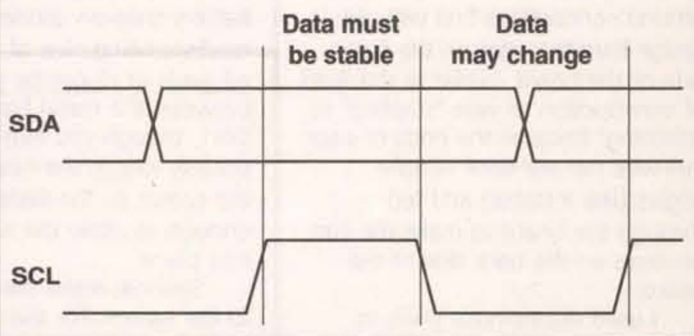


FIGURE 6. Relationship between I2C Data & Clock



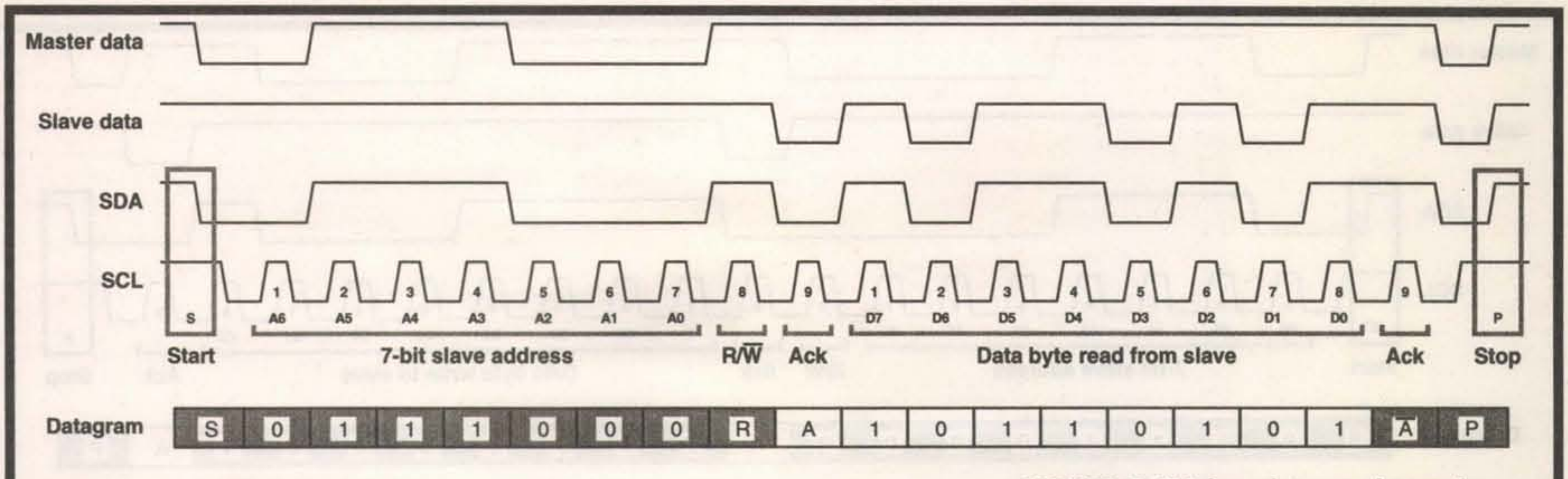


FIGURE 7. I2C bus data read transfer

condition.

Assuming the slave is present and able to respond, though, the slave becomes the transmitter; it ACKs, then drives its data bits onto SDA, and the master clocks them in. Again, the master must release SDA so the slave can drive its data onto the line.

PHOTO 4

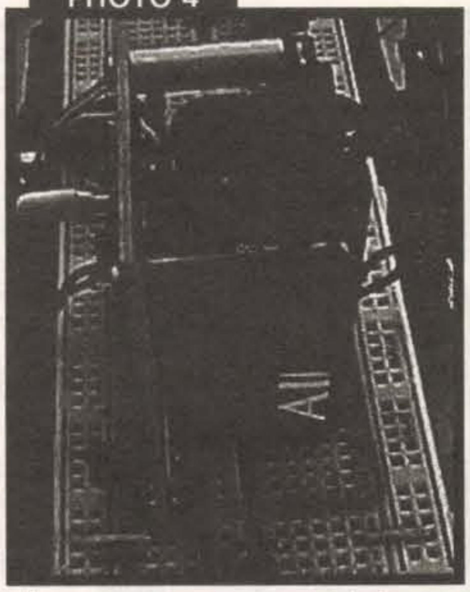
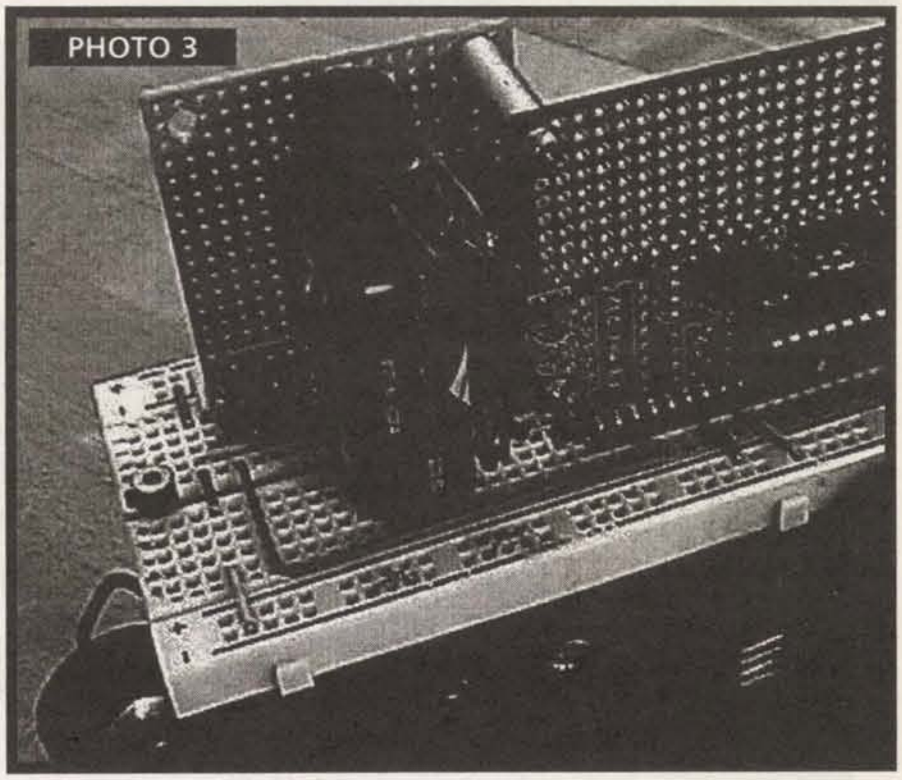


PHOTO 3



ACK or NACK?

On the I2C bus, each byte transmitted must be acknowledged by the IC that receives the byte, with the following exceptions: 1) when a slave-receiver cannot receive any more data (its data buffer is full, for instance); or 2) when a master-receiver wants to signal that a read operation is done. In these cases, the receiver generates a not acknowledge (NACK) pulse by releasing SDA to float high during the ACK clock pulse. A slave-receiver in this situation must then release SDA.

Another way of saying this is an acknowledge of a byte received from a slave is always necessary except on the last byte received. Why? An I2C slave will keep transmitting data unless it's told not to.

If the master generated a normal ACK pulse, the slave would again seize control of SDA to transmit the first bit of the next byte. If that bit happened to be a zero, the master would be unable to generate a STOP condition because the slave would be holding SDA low waiting for the next clock pulse.

But, if during the ACK clock pulse, the master leaves SDA high, then the slave knows it must release SDA and not drive with it with new data after the ACK cycle is over. In this way, the master is free to bring SCL high then bring SDA high to create the STOP condition.

Note that NACK is not the same as a no acknowledge condition. Both involve SDA being high during an ACK clock pulse, but NACK is the master telling the slave not to transmit another byte, while no acknowledge is the state of the bus when a slave can't respond to a master. Because Figure 7 depicts a single-byte read transfer, when that data byte is read, it is, perforce, the last byte, so the master must generate a NACK.

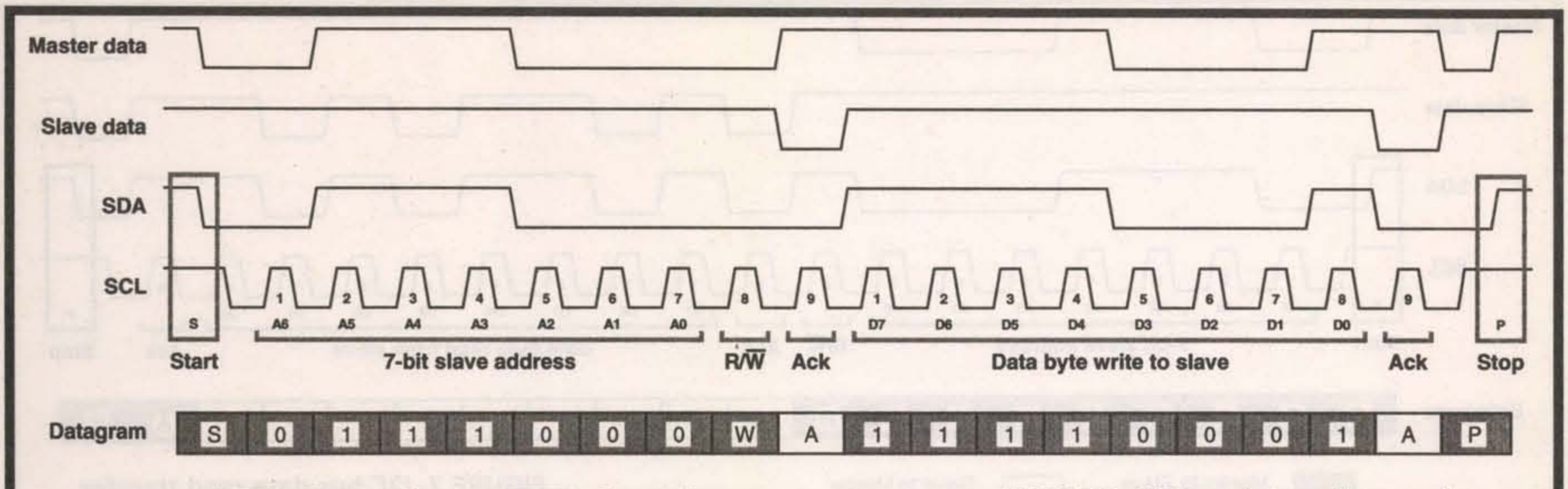


FIGURE 8. I2C bus data write transfer

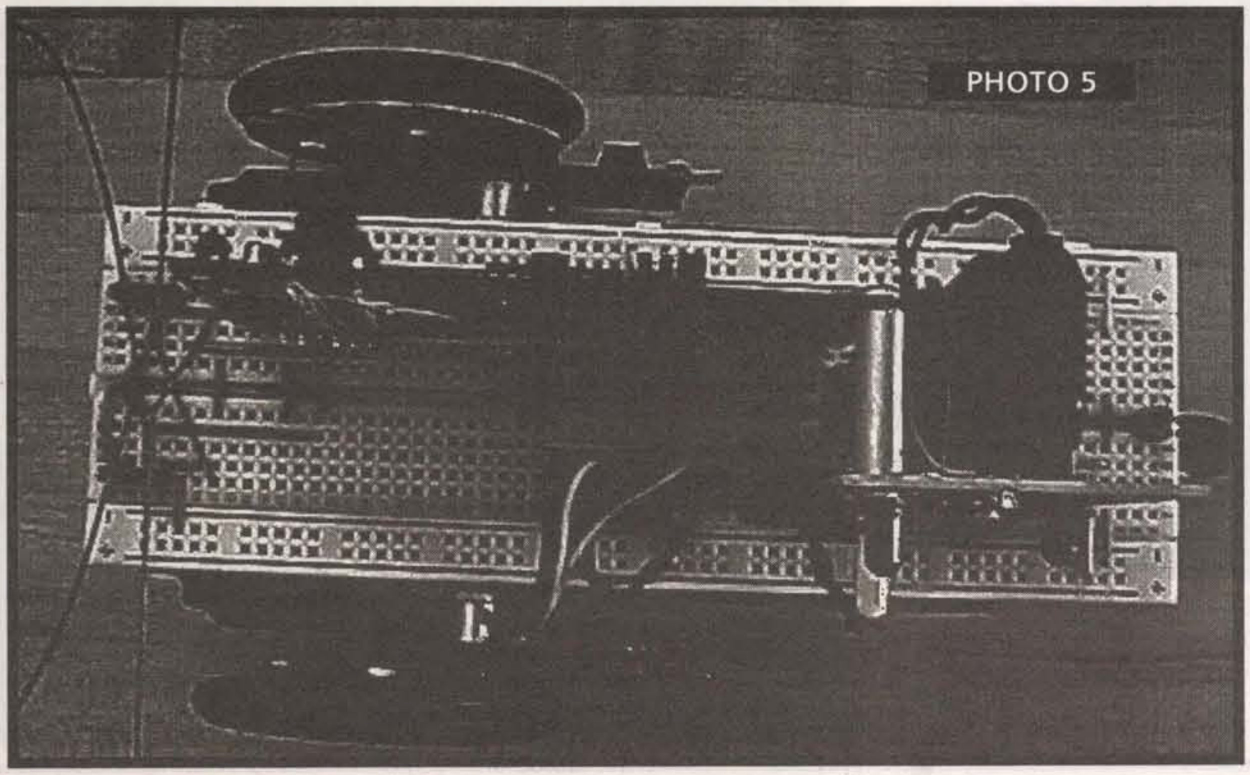


Figure 8 shows a data write operation where the binary data 11110001 is being written to the same slave as in Figure 7. Since this is a write, the master is in control of SDA except during the ACK cycles so there is no problem with generating a STOP condition.

(If your head isn't ready to explode yet, then you either already know all about I2C or you weren't paying attention. Go back and reread the above sections a few times until it all makes sense).

Next time, I'll get into the intricacies of multi-master bus arbitration, clock synchronization, and the timing parameters of the SDA and SCL waveforms. Now, though, I'll switch topics to my new ...

Robot Development System

The beginnings of my robot development system came when I realized about six months ago that I could no longer afford commercial development software. It's not just a matter of money (though that is an issue), but of time and energy expended getting commercial apps to work.

I spend a significant amount of time recovering from application crashes. I'm not talking about experimental, use-at-your-own-risk beta versions, but well-established, supposedly solid commercial programs.

And I still get hangs and crashes at least three times a week. I've done all the usual stuff with Norton Utilities and have spent countless hours on the phone with the software companies, but none of it helps.

Now, I'm a confirmed Mac user, but I do use DOS and Windows for certain purposes. And, even though I find the Mac easier to use for most jobs, I see no difference at all between my Mac and DOS and Windows machines in the number of application crashes that also crash the OS. Commercial software – especially commercial operating systems – devour too much of my time.

There is out there, though, an OS legendary for almost never crashing, with uptimes measured, not in days, but in months and years.

Linux.

Individual applications may still crash, but they don't take Linux down with them. And Linux is very low-cost (free if you download it). To understand Linux's extraordinary reliability, take a look at the Linux resource sidebar. In particular, I recommend reading the papers by Eric S. Raymond. I knew there was something special going on in Open Source software, but I didn't really understand why until I read these papers. Recommended.

There's not much mobile robotics development software commercially out there anyway, Mac or PC, and what there is I can't afford. This points toward leveraging public domain and university AI software and research, and using free software programming tools wherever possible. Most university software is meant to run under some version of Unix, and hence, will run under Linux.

More Horsepower

On the hardware side, I'll use current generation desktop ATX motherboards to develop code for next generation embedded controllers. Don't worry, I'm abandoning neither Breadbot nor low-end microcontrollers. I want to increase the amount of computing power I can throw at some problems, that's all.

The advantage is that desktop motherboards are dirt-cheap, standardized, and universally available;

PARTS

Item	Description
C1,C2	10µF, 16V tantalum
J1	2-pin right angle male Waldom connector
J2, J4	4-pin right angle male header
J3	9V transistor battery snap connector
LED1	Red high efficiency LED
R1	6.8k ohm, 1/4 W, 5%
SW1	DPDT switch, 3-position, center OFF (RadioShack #275-1545 or similar)
Misc:	
	0.8"x1/4" dia. 4-40 threaded aluminum spacer
	1.80"x2.05" perfboard, 1/10" hole spacing

I2C links:

www-us2.semiconductors.philips.com/i2c/
www.ping.be/~ping0751/i2cfaq/i2cfaq.htm
www.mcc-us.com/i2chowto.htm

Linux and Open Source Software links:

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Voice: 617-542-5942 • Fax: 617-542-2652
www.fsf.org
www.gnu.org

The Linux Home Page
www.linux.org

The Linux Journal
www.linuxjournal.com
(the oldest paper magazine devoted to Linux)

Linux Magazine
www.linux-mag.com
(a new upstart paper 'zine)

The Linux Mall
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Open Software Foundation
The Open Group
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www.opengroup.org

uCLinux:
ryeham.ee.ryerson.ca/uClinux/
(Small footprint Linux for embedded processors without MMUs)

Papers by Eric S. Raymond:

"The Cathedral and the Bazaar"
www.tuxedo.org/~esr/writings/cathedral-bazaar/

"Homesteading the Noosphere"
www.tuxedo.org/~esr/writings/homesteading/

"The Magic Cauldron"
www.tuxedo.org/~esr/writings/magic-cauldron/

the disadvantage is that ATX boards are power hungry, consuming 20 to 30W on the DC side of the power supply (less, actually; the 30W typically includes various floppy, CD-ROM and hard drives, and a video card).

By the time my code is debugged and fleshed out, I figure lower-power embedded Pentium systems will be available – say, in PC/104 form factor, and maybe they'll even be affordable. In the meantime, I trade off battery life for more computing horsepower. Plus, I can be secure in knowing that the target controller board is truly identical with my desktop development system.

Okay, so this is my $1,600.00 budget baseline system:

- ABIT BX6-2 motherboard
- 366 MHz Celeron
- 64 MB of PC-100 ECC SDRAM (expand to 1 GB as memory prices fall)
- AGP video accelerator
- 19" Mitsubishi Diamond Pro 900U monitor
- 8.4 GB IDE hard drive
- 32X CD-ROM
- Upgrade slot 1 CPU to faster Pentium II or III in a year
- ATX mid-tower case, modem, mouse, keyboard, etc.

From what I've read and heard, ABIT's BX6-2 motherboard is quite stable, even when overclocked. Maybe its best feature, though, is that it incorporates their Softmenu BIOS, which eliminates all on-board jumpers. Softmenu allows varying CPU clock and voltage so I can experiment with power consumption vs. speed tradeoffs:

- CPU voltage variable from 1.30 to 2.30V in 0.05V increments
- Supports bus multipliers of 2-8X in 0.5X increments
- Supports bus speeds from 66 to 133 MHz

All the pieces have arrived. Now all I have to do is put this monster together. You'll hear more about that, as well as I2C and Breadbot, next time. **NV**

As always, if you have suggestions for improving Breadbot, if you've built a Breadbot, or if you have questions or comments about amateur robotics topics, you can reach me at:

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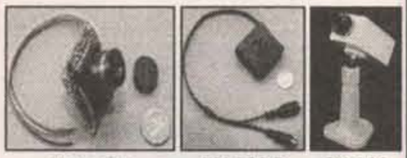

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SPDT	D129	6A/125V	Solder	.77	.67
mom-off-mom		3A/250V	Solder		
SPDT	D134	6A/125V	Solder	.77	.67
on-off-on		3A/250V	Solder		
DPDT	D133	6A/125V	Solder	.77	.67
DPDT	D135	6A/125V	Solder	.92	.82
on-off-on		3A/250V	Solder		
DPDT	D130	6A/125V	Solder	.92	.82
mom-off-mom		3A/250V	Solder		
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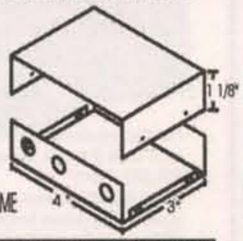

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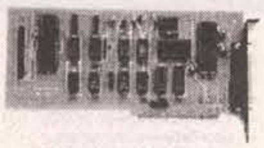

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capacitor of the second 555 timer (right), which generates the sweep needed for the scope display. Be aware that this is just an expanded block diagram (I've never built it) and the values listed are only ballpark figures — values that you can start with, but will have to tweak to match your scope's and car's needs. If you run into problems using an inductive pickup, I suggest an NE2H neon lamp coupled to a homemade optical sensor using shrink tubing.

I-Worm.ExploreZip Cures — Free!

A new Internet Worm virus, called I-Worm.ExploreZip (I've seen it spelled many different ways), is hitting corporate networks and end-user PCs around the world at an extremely rapid pace. Once a PC is infected it will reply using MAPI to every E-Mail received by that PC. The reply E-Mail contains a copy of the worm and reads as follows:

oHi "name of recipient" !
oI received your email and I shall send you a reply ASAP.
oTill then, take a look at the attached zipped docs.
oSincerely

I-Worm.ExploreZip contains a very malicious payload. It uses Microsoft Outlook or Microsoft Exchange's MAPI to mail itself out by replying to the messages you receive. It attaches a file called "ZIPPED_FILES.EXE" that, upon execution, infects the recipient's PC. Unknowingly, users execute the attachment since it has the familiar icon of a Winzip file and it apparently comes from a known source or friend.

Fortunately, it's not a very destructive virus in that lost data can be recovered. Unfortunately, some companies are capitalizing on this malady, to the tune of hundreds of dollars. I did a search of the web — with the help of http://www.internetwire.com — and found three top-notch companies that are willing to fix the problem for free. Here they are.

- **Emergency Undelete**, a free utility originally developed to recover accidentally deleted files from Windows NT network disks, is being used by companies all over the world to help recover data destroyed by the ExploreZip worm. It can be downloaded free at **http://www.undelete.com.**
- **GFI**, leading developer of E-Mail security and management software, offers a freeware version of Mail essentials for Exchange/SMTP that's able to protect a corporate E-Mail system from the dangerous data-destroying E-Mail virus, Worm.ExploreZip. Other anti-spam features in the freeware Mail essentials version include checking for incorrect "From" headers and addresses in the E-Mail body, real-time black hole list support and more. The freeware anti-spam version can be downloaded from: **http://www.gficomms.com/mes index.htm**. The download contains all the Mail essentials features, valid for 60 days; however, the anti-spam feature does not expire and remains fully functional.
- **Panda Software** has added detection and disinfecting of this extremely dangerous Internet worm to their software programs, and has posted free "good-riddance" software on its website at **http://www.pandasoftware.com.**

TJ Byers
Q & A Editor

MAILBAG

Dear TJ:

Regarding your May '99 answer for the reader wanting a VGA cable for his Macintosh IIsi, the IIsi and earlier Macs don't do VGA. They have only a couple of scan modes and VGA isn't one of 'em. The IIsi does 640 x 480 at Apple's own 67 Hz rate. The first Macs to do VGA, at 60 Hz, were the LCIII — the model released after the IIsi. So, while your info about how to build a VGA cable for Mac is correct, it won't be helping the particular reader who requested it. I suspect that some SVGA monitors can handle this, but none that I have in house. Also make sure to tell the reader to wire the cable for 640 x 480 mode.

Fred Martin
via Internet

Response:

I wasn't aware that the scan rate changed somewhere between models. Neither did my sources, who sell this adapter cable. In case you missed the answer, here is the pinouts of the adapter again — corrected for SVGA monitors that can do 640 x 480 at 67 Hz. Thanks Fred!

TJ Byers
Q & A Editor

Mac IIsi Pin	SVGA monitor Pin	Function
1	6	Red GND
2	1	Red
3	--	Composite TTL sync
4	--	Monitor sense 2
5	2	Green
6	7	Green GND
7	--	Monitor sense 1
8	--	not used
9	3	Blue
10	--	Monitor sense 0
11	--	GND
12	14	Vertical sync
13	8	Blue GND
14	10	Horizontal sync GND
15	13	Horizontal sync

Dear TJ:

I read with interest your remarks on GR Variacs in the June '99 issue, but was sorry you did not remark on the real novelty of the Variac design: the use of a graphite brush which made contact with several turns of the winding at once, but had enough resistance to not load the nearly shorted turns too much. This feature provides a smoothly adjustable voltage rather than steps as would have been the case of a metallic contact moving from turn to turn, and not touching two at once.

Bob Meade
via Internet

Servos, Steppers, and Optical Encoders — Part I

by TJ Byers

Which one works best in your robotic or R/C project?

Here's everything you need to know.

Whether you play with robots, model planes, or boats, there are motors inside which supply the muscles and habits that make them go. Choosing the right motor for your project, though, can be a daunting experience. Motors that provide locomotion aren't the same as those that move robotic arms or guide a plane.

Basically, controller motors come in three flavors: servos, steppers, and encoders. Each operates differently and each performs a specific task. In this discussion, I explain the differences between the three and their application. I'll also show you the control circuitry needed to make them perform as expected.

Unfortunately, the length of my discoveries ran a lot longer than I originally planned, and longer than the editor is willing to put up with in a single issue, so I've broken it up. The first part deals with servos. It includes all the theory you ever wanted to know about servos, and were sorry you asked. It also includes the circuitry needed to make your servo jump through hoops.

The next installment is on stepper motors — which aren't servos! Steppers spin, and servos actuate. So, with that in mind, let's take a look at servos.

Servos

The term "servo" actually defines any system where a small force controls a larger one, and encompasses both mechanical and electrical controllers. In the electronics and hobby world, the word servo usually means an R/C (remote control) servo motor — the kind typically found in model airplanes and RadioShack cars.

Of course, they find widespread use in robotics, too. This is the type of servo I'll focus on in this article.

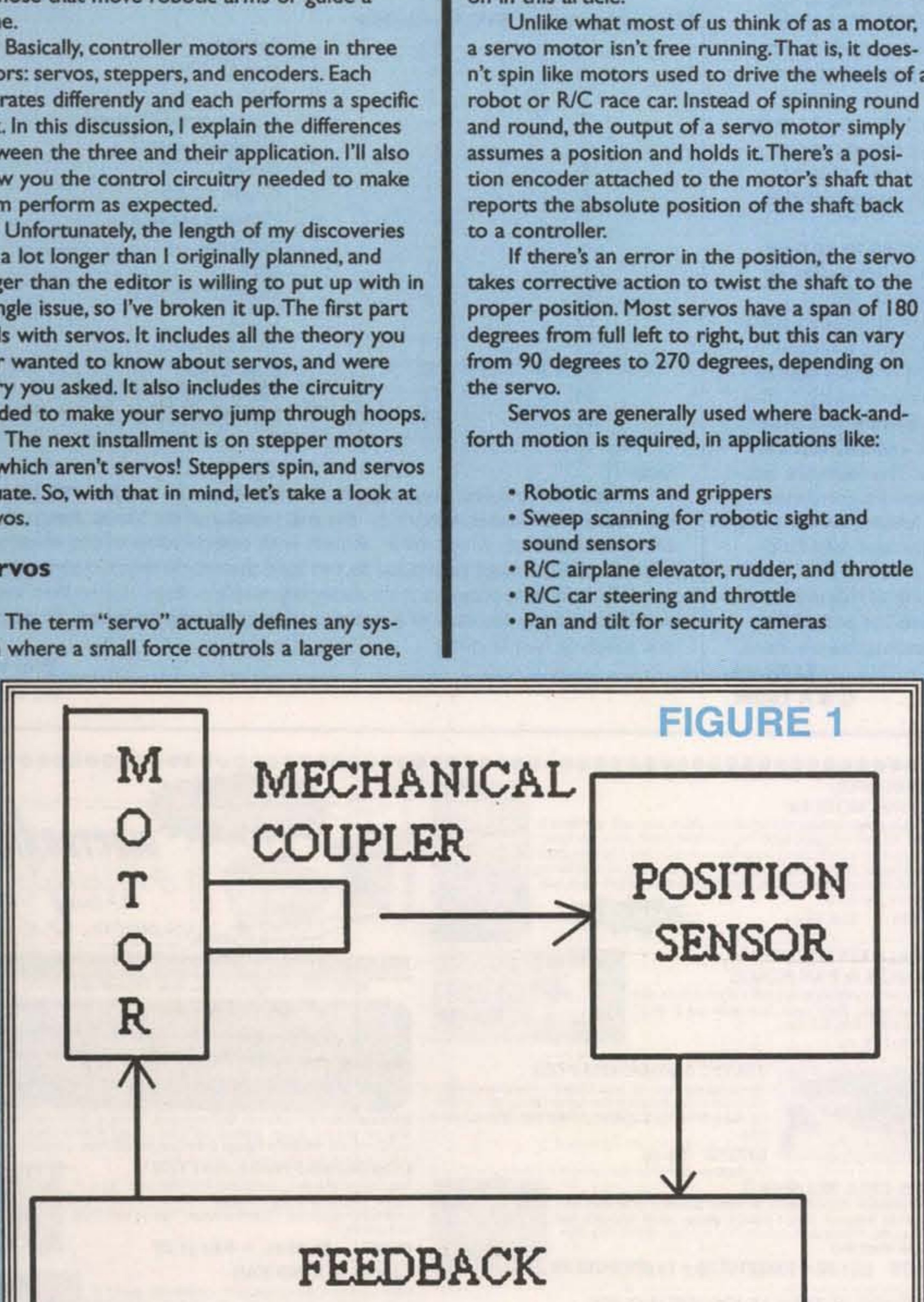
Unlike what most of us think of as a motor, a servo motor isn't free running. That is, it doesn't spin like motors used to drive the wheels of a robot or R/C race car. Instead of spinning round and round, the output of a servo motor simply assumes a position and holds it. There's a position encoder attached to the motor's shaft that reports the absolute position of the shaft back to a controller.

If there's an error in the position, the servo takes corrective action to twist the shaft to the proper position. Most servos have a span of 180 degrees from full left to right, but this can vary from 90 degrees to 270 degrees, depending on the servo.

Servos are generally used where back-and-forth motion is required, in applications like:

- Robotic arms and grippers
- Sweep scanning for robotic sight and sound sensors
- R/C airplane elevator, rudder, and throttle
- R/C car steering and throttle
- Pan and tilt for security cameras

FIGURE 1



Servo Construction

Servos are constructed from three basic elements: a motor, a feedback device, and a feedback loop (Figure 1).

Servo Motors

For hobby and robotic applications, DC motors are preferred over AC motors because they generate greater torque for their size and weight. The output from the motor's shaft is connected to a gearbox (usually called a gearhead) that reduces the motor's speed to a usable output speed. The gearhead ratio between the RPM speed of the drive motor and the output shaft determines the response time and the torque of the servo.

The torque is measured in inch ounces, usually listed as oz-in or oz/in. The listed torque is the maximum force the servo will exert on an object one inch from the shaft. The farther away from the shaft you go, the less torque is available. The formula is simple:

Torque = Distance x Force

Let's say the servo is rated at 100 oz-in. This means it can lift a 100-ounce weight when the weight is attached one inch from the shaft. Move that point out to two inches, and the force drops to 50 ounces. Three inches is 33 ounces, and so forth. Most servos have a torque that falls somewhere between 10 oz-in and 300 oz-in, with the popular hobby models within the 20 oz-in to 150 oz-in range.

The higher the input-to-output gearhead ratio, the greater the output torque — but the lower the output RPM. The slower the shaft turns, the more time it takes for the servo to respond to changes in shaft position. Depending on the servo, the response time can be anywhere between 0.10 and 1.5 seconds. The faster ones are used for airplane surface controls and the slower ones, which usually have higher torque, are used in sailing ships to raise the sail.

The construction of the gearhead is critical to servo life. Most of the hobby models use plastic gears that often wear out after 100 hours of use. If the servo is energized but not moving, as in a holding state, that time doesn't count — just the motion time. Adding to the longivity problem of these low-end servos is the shaft bearing which is plastic, too. Medium-priced servos have metal gears and a metal bearing that stand up

Servos, Steppers, and Optical Encoders — Part I

better under heavy use. At the top of the line, you'll find heavy-duty gearheads with ball-bearing bushings.

Servo Feedback

Critical to servo operation is a position sensor: a device that monitors the angle of the shaft and feeds it back to the controller. In virtually every case, the sensor is a potentiometer (variable resistor) wired in a ratiometric feedback configuration (Figure 2).

In this configuration, the wiper of the potentiometer is tied to the positive input of an error op amp. The top of the potentiometer is connected to Vcc (typically +5 volts) and the bottom is returned to GND. The potentiometer shaft is physically attached to the output shaft using a 1:1 ratio gear so that the potentiometer is in step with the output shaft.

The negative input of the error amp is connected to a reference volt, the value of which is set by the pulse width on the signal wire. (More on that later.) This voltage sets the position of the servo shaft. When the voltage across the potentiometer wiper equals that of the reference voltage, the control circuit stops the motor and locks the shaft into position.

For the sake of argument, let's set Vcc at +5 volts (typically Vcc servo voltages range from 4 to 6 volts). This means that a reference of 2.5 volts will set the shaft position to exactly one-half of the servo's full sweep. Likewise, 1.25 volts is one-quarter of the sweep, and 3.75 volts is three-quarters of the sweep — plus all of the increments in between.

Like the gearhead, the potentiometer is a source of potential failure — and inaccuracy. In many cheap servos, the potentiometers are made of plastic, which get gritty, and wear out rather quickly. What happens is that the servo will jitter or hunt for an exact position. Not surprisingly, the lifetime of the gearhead is matched to that of the potentiometer. Both wear out at just about the same time. Medium-priced servos generally have sealed potentiometers to keep the dust out and make the potentiometer last a lot longer. Again, the quality of the metal gears is paired with the potentiometer for an equal lifetime.

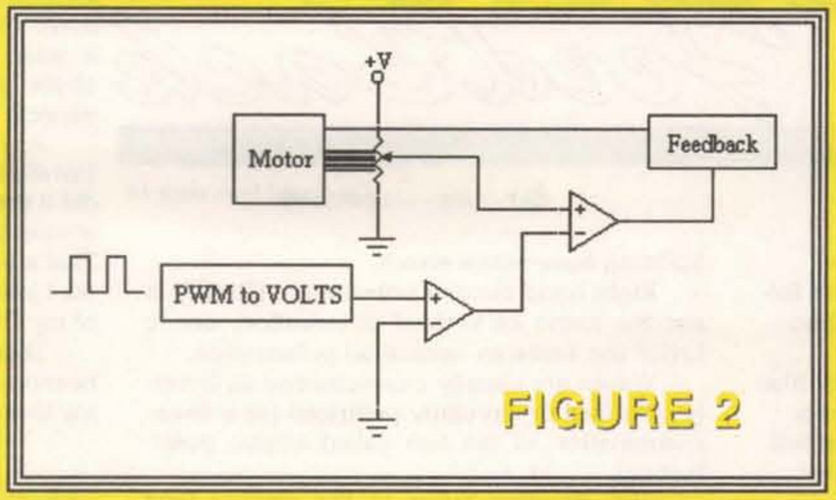


FIGURE 2

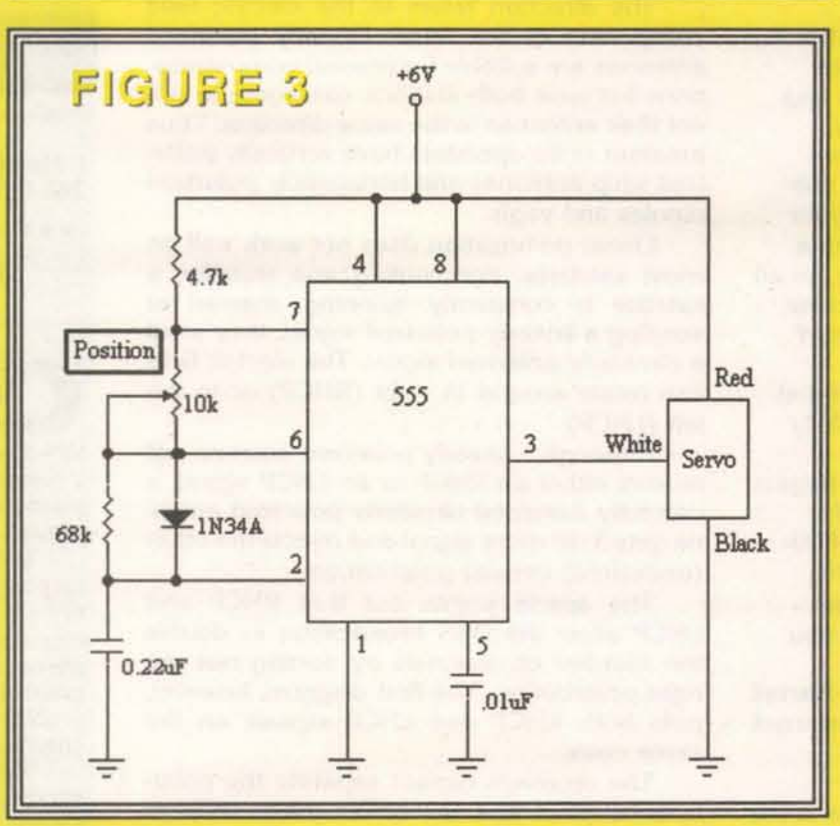


FIGURE 3

Servo Control

Now that you're totally bored with servo motor theory, here's some real hands-on stuff. Specifically, what does it take electronic-wise to make the servo shaft turn? Surprisingly, not a lot; a single 555 timer chip makes an excellent servo controller.

As explained above, it's a changing reference voltage that positions the shaft. This reference voltage is derived from an input pulse to the signal or control wire (typically white). The reference voltage is derived from the width of the signal input pulse, not the repetition rate. The range is between 0.5 mS and 2.5 mS, depending on the particular servo, with 1.5 mS defined as mid range — halfway through the sweep regardless of the sweep arc.

Put in the scenario above, if the input pulse is 1.5 mS, then the reference voltage is 2.5 volts, and the shaft's rotation is resting at half rotation. Assuming that we have a typical 180-degree servo with a 1 mS to 2 mS pulse width range, a 1 mS pulse sets the servo shaft position at 0 degrees and a 2 mS pulse twists the dial to 180 degrees; 1.5 mS puts it at 90 degrees.

This timing is independent of the servo's Vcc or rotational range: 1.5 mS always sets the sweep at mid scale. Keep in mind, though, that the minimum and maximum pulse widths will vary from servo to servo, and should not be exceeded. If you try to command the servo to a position beyond its physical limits, it will hum, jitter, and eventually burn out.

However, servos will not hold their position forever. The signal pulse must be repeated periodically for the servo to stay in position. The maximum amount of time that can pass before the servo will stop holding its position is called the command repetition rate, usually every 10 mS to 40 mS — about 20 Hz to 80 Hz. You can repeat the pulse more often than this, but not less often. If the repetition rate drops below 50 mS, the servo ceases to be a servo and, instead, becames a "98-pound weakling" that can be shoved around.

Table 1. Wire colors for popular servo motors

Mfg	Positive (+)	Negative (-)	Signal
Airtronics	Red	Black	Brown
Sanwa	Red	Black	Black stripe
Futaba J	Red	Black	White
KO Propo	Red	Black	Blue
Pulsar Kyosho	Red	Black	Yellow
Japan Radio(JR)	Red	Brown	Orange

Servo Drivers

Okay, here's the circuit you've been waiting for (Figure 3). The 10k position potentiometer adjusts the pulse width between 1 mS and 2 mS, the range typically used in small hobby (40 oz/in) servos, with the center setting generating a 1.5 mS pulse width. The pulse repeats every 20 mS, for a repetition rate of 50 Hz. The 1N34A is a pulse shaping diode that sharpens the fall time. The red and black servo leads are +6 volts (Vcc) and GND, respectively, and the white lead from the servo is the control wire.

Trust me. This circuit works all the time — done it, been there. If you need a bigger sweep, you can try stretching the pulse width limits by increasing the value of the 68k resistor. But at the first sound of chatter, back off. You've hit the limit.

Not Done Yet!

No, there's a lot more to come. Just remember that servos actuate — move like limbs — and steppers rotate — like fan motors. With that in mind, we'll continue this discussion next time.

Next time, I'll serve up a full platter of stepper motor theory and circuits. **NV**

reader FeedBack

Continued from page 16

Also, since crystals cannot easily be made for very high frequencies, it will be followed by a multiplier chain which will then double or triple the output frequency.

Along with that information, you will also have to know if it is series or parallel resonant, how much capacitance the crystal will be working with in the oscillator, and the required frequency tolerance.

In short, you need to know all of what the designer of the radio knew when the original crystal was specified, and that was much more than just crystal frequency.

Rather than try to engineer your own crystal, the easiest path is to call up a custom crystal grinder and order one for your specific radio and frequency. They keep a database of the necessary information, so all you need to do is to tell them what receive frequency you want and they take care of the rest.

A good Internet source can be found at www.geocities.com/CapeCanaveral/8701/mega/xtals.htm

Listed on that page are two of the largest and oldest custom crystal makers: JAN Crystals, Ft. Myers, FL 33906-6017, 1-800-526-9825; and ICM, Oklahoma City, OK 73126-0330, 1-800-426-9825. Give these folks a call and they can probably get you what you need in a week or so.

Dave Sarraf
Via Internet

Dear Nuts & Volts:

The bridge circuit offered by TJ Byers in the April '99 issue (page 77), and the "corrected" circuit given in July '99 (page 34), have dangerous short circuits across the power line.

In the July circuit, the lower quad's NW diode and the upper quad's SW diode short the power line on positive excursions. The negative excursion is shorted by the upper SW and lower NW diodes. The circuit is dangerous and should not be used. The short circuits are present because the circuit is trying to connect the 115 VAC line across the upper and lower capacitors at the same time.

Reasonable simple circuits are a 160V full-wave single supply (using four four diodes) or a ±160V half-wave supply (using two diodes). Since the application uses a transformer, there is no need for a 320V supply, making a 160V full-wave supply a good bet.

Be careful when working with the power line. The schematic should have a fuse in the power lead to guard against shorts caused by wiring or design errors. When testing power line circuits, keep one hand in your pocket and use a GFCI.

Gerald Roylance
via Internet

Dear Nuts & Volts:

TJ Byers' comments about DSS Signal Splitting have some errors.

Right hand circular polarization (RHCP) is not the same as vertical polarization, nor is LHCP the same as horizontal polarization.

Waves are usually characterized as linearly polarized or circularly polarized (or a linear combination of the two called elliptic polarization).

The direction refers to the electric field component of the wave. Linearly polarized antennas are suitable for ground communications because both stations can agree to orient their antennas in the same direction. Thus amateur radio operators have vertically polarized whip antennas and horizontally polarized dipoles and yagis.

Linear polarization does not work well on most satellites. For cooling and stability, a satellite is constantly spinning. Instead of sending a linearly polarized signal, they send a circularly polarized signal. The electric field can rotate around to right (RHCP) or to the left (LHCP).

Although a linearly polarized antenna will receive either an RHCP or an LHCP signal, a correctly designed circularly polarized antenna gets 3 dB more signal and rejects the other (undesired) circular polarization.

The article points out that RHCP and LHCP allow the DSS broadcaster to double the number of channels by sorting out the right polarization. The first diagram, however, puts both RHCP and LHCP signals on the same coax.

The receivers cannot separate the polarizations (that was the LNB's job!), so both receivers will produce trash.

There is another reason why a splitter isn't a good idea, and Mike Quinn guessed it when he thought the signals might be too weak. Signal-to-noise ratios are important for DSS broadcasters, and using a passive splitter will lower the SNR by at least 3 dB. A lower SNR means more bit errors, so your MPEG decoder will generate more trash, especially when it rains.

That aside, there are DSS splitters for sale, and they skirt the DC signaling voltage fights by putting a DC block in one leg. Ordinary TV splitters (50-500 MHz) don't have the frequency range for satellite signals (1-2 GHz).

The bottom line is you need a dual LNB for complete independence of the set-top boxes. When you get to three set-top boxes, there are multiplexers that connect to a dual LNB and provide three DSS ports.

Some of these multiplexers will even combine the signal from a local TV antenna so you don't need to run two cables (one satellite TV, one ordinary TV) to each receiver.

Gerald Roylance
via Internet

Response:

Right hand circular polarization (RHCP) is not the same as vertical polarization, nor is LHCP the same as horizontal polarization. I know the difference between polar, vertical, and horizontal polarization. The people at the Good Guys don't. That's why my answer was worded the way it was. Many sales people doen't even know about polarization, much less the technical aspects of circular vs. polar.

As to the block diagram, that came from an installation manual. BTW, the reader who asked, did it the way I suggested, and it works. I always answer the question online before printing them. That's not to say I don't make mistakes, 'cause I do; I just try to minimize them. Check out some of my DSS answers in earlier columns.

Thanks for your input, and look forward to hearing from you in the future. You keep me on my toes.

TJ Byers

Newsbytes

Continued from page 16

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FULL SERVICE FOR YOUR PC

Continuing in its tradition of producing superior PC utilities, Iolo Technologies announces a new set of tools for Windows 95, 98, and NT. System Mechanic 3.0 is a complete suite of 10 utilities, providing the essential preventative maintenance today's PCs require.

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"Computers are not appliances like microwave ovens or washing machines — an automobile is a much better comparison," says Noah Rowles, president of Iolo Technologies, "All computers need regular maintenance and similar to your car, will begin to run poorly or even break-down if not routinely serviced. System Mechanic is a product built around extensive research into the most common PC problems and the result is a complete set of tools that allow you to comprehensively maintain your computer system."

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System Mechanic 3.0 will be available in June 1999 directly from Iolo Technologies for $59.95. It requires Windows 95, 98, or NT with at least 8 MB of RAM and 2 MB of free disk space. A 30 day trial version is available at www.iolo.com. For more information, contact **Iolo Technologies** at **626-793-3993** or **877-239-IOLO** or visit **www.iolo.com.**

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Build an LED Digital Thermometer

by Fred Blechman

The LED Digital Thermometer — which can be assembled from an under-$38.00 kit or from scratch — can measure temperatures in all kinds of environments from -040 degrees to +100 degrees Centigrade or (with modification) from -040 degrees to +212 degrees Fahrenheit.

Designed with a probe for dipping in liquids, it can also be used for ambient temperature measurements. Three large seven-segment LED digital displays provide visibility in darkness.

Background

Several types of measuring "instruments" are in common use. For example, most homes use measuring cups to measure volume, scales to measure weight, clocks to measure the passage of time, and thermometers to measure temperature. Modern technology has provided digital readouts for many of these devices.

Initially, light emitting diodes (LEDs) using seven-segment digital displays were used. These were easily readable in the dark, but difficult to read in daylight. More recently, liquid crystal displays (LCDs) — unreadable in the dark without a special "backlight" — have become popular. LED digital clocks and digital weighing scales are still common, but LED digital thermometers — readable in the dark — are relatively rare or very expensive.

Measuring Temperature

The most common (and least expensive) thermometer consists of a closed glass tube filled with a colored organic liquid — such as alcohol — of known thermal expansion. The expansion is small, being about one thousandth of the original volume per degree Centigrade for alcohol. The more expensive (and more accurate) thermometers use mercury as the liquid, such as in clinical thermometers used to measure body temperature. The "height" of the liquid column in relation to an engraved calibrated scale indicates temperature.

Another common thermometer is the wall-mounted type with a large circular dial. Some of these consist of a spiral capillary tube with either liquid or gas that changes state or phase with temperature. The changing pressure or the volume in the system activates gears and levers to move a pointer above the circular scale. Others — such as common wall thermostats — typically use a spiral bimetallic strip that depends on the differential thermal expansion of two dissimilar metals. As the temperature changes, the spiral strip curls or uncurls, resulting in movement of the pointer (or mercury switch) by mechanical coupling.

None of the above thermometers lend themselves to electronic temperature measurement beyond "on" or "off." However, many metals, semiconductors, and ceramics change their electrical resistance with temperature in a known and reproducible manner.

This change in resistance results in a change of current or voltage, so it can be measured and then displayed in an analog or digital fashion. This is the basis for the digital thermometer assembled in this construction project.

Digital Thermometer

The CEKIT K-038 Digital Thermometer — which can be assembled from a kit or from scratch — can measure temperatures in all kinds of environments from -040 degrees to +100 degrees Centigrade, or with modification, from -040 degrees to +212 degrees Fahrenheit.

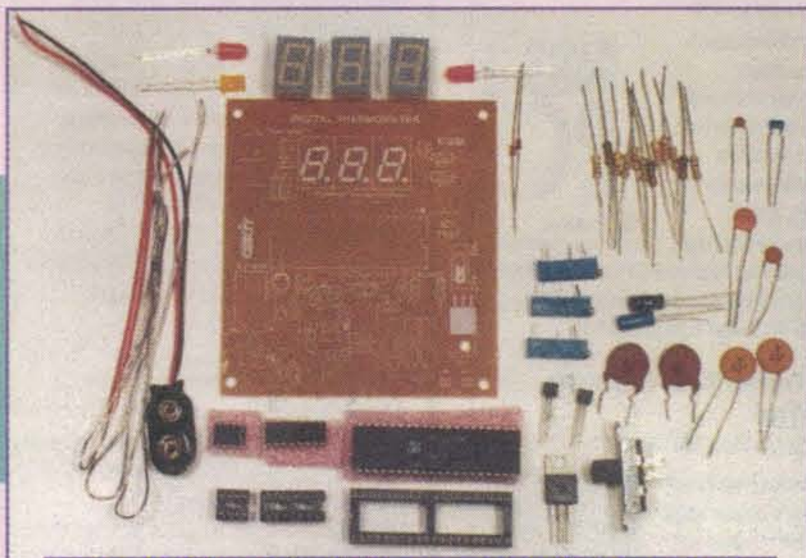
The temperature sensor can be mounted at the end of a cable or probe for dipping in liquids, or it can be used for ambient temperature measurements. For example, in repairing electronic equipment, the probe could be used to monitor the temperature of an electronic component suspected of overheating.

Three .56-inch-high red LED seven-segment digital displays provide visibility in darkness. Although designed for short-time portable battery use, we include the simple changes to allow use with plug-in external power that disconnects the battery, allowing constant operation.

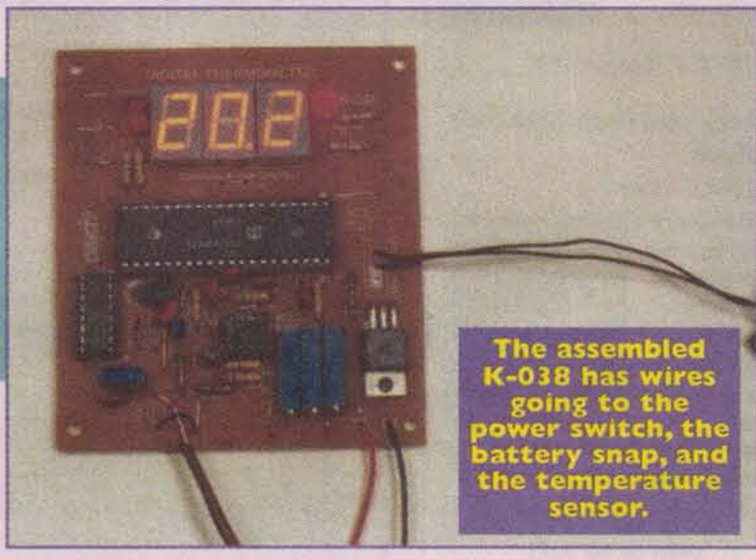
Although originally designed for measuring temperature in Centigrade (where 000-degrees is freezing, and 100-degrees is the boiling point of water), we describe the few changes to have it read in Fahrenheit (where 032-degrees is freezing and 212-degrees is the boiling point of water). We also include a temperature conversion table and formulas.

It should be mentioned at this point that some of the parts necessary for this project may be difficult to find, or expensive. For example, we checked the price of the 40-pin ICL7107CPL 3-1/2-digit A/D converter 40-pin DIP integrated circuit from Thompson Consumer Electronics (their stock number SK10279) — $25.00! Mouser has it for under $7.00. The three seven-segment displays cost about $2.00 each — if you can find them! And the LM335 temperature sensor integrated circuit may be available only from National Semiconductor distributors; we could not find a mail-order source or price.

On the other hand, the K-038 kit includes ALL parts and solder, plus a silkscreened etched and drilled printed circuit board, for a kit price of $37.95.



The K-038 Digital Thermometer Kit has many parts, including a fairly complex silkscreened printed circuit board.



The assembled K-038 has wires going to the power switch, the battery snap, and the temperature sensor.

Circuit Operation

For an overview of how the K-038 works, look at its block diagram, Figure 1. A known reference voltage is provided by IC4. This is amplified and adjusted by IC3 and fed to one input of the analog/digital converter, IC1. At the same time, the temperature sensor, IC5, feeds a voltage that depends on temperature to the other voltage input of IC1.

IC1 is designed to compare the two voltage inputs and, using internal dual-slope conversion and drive circuitry, provides the appropriate outputs to light common-anode seven-segment LED displays.

LED Digital Thermometer

The schematic (Figure 2) shows the complete circuit, and allows a more complete description of exactly how all this occurs. Obviously, the heart of the entire device is IC1, an ICL7107CPL 40-pin plastic dual-inline-pin (DIP) integrated circuit.

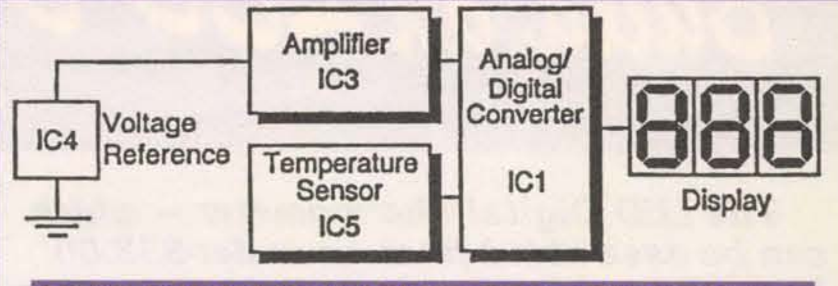


Figure 1: K-038 Digital Thermometer Block Diagram

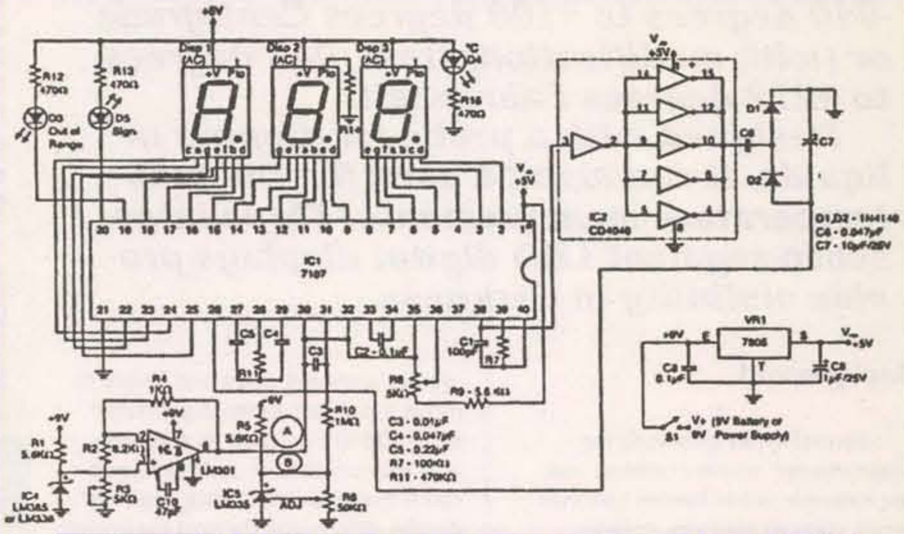


Figure 2: K-038 Digital Thermometer Schematic

The pinouts of IC1 are shown in Figure 3. IC1 is designed to operate from a +5V and -5V supply. However, to operate from a single +5V supply, a negative supply can be generated from OSC 3 pin 38 of IC1 with two diodes, two capacitors, and an inexpensive IC. As shown in Figure 2, IC2 — a 16-pin CD4049B hex inverter — C6, C7, D1, and D2 perform this function, and provide a DC voltage to pin 26, the V- pin of IC1.

Internal IC1 circuitry connected to pins 38, 39, and 40 is used with capacitor C1 and resistor R7 to create an oscillator operating at about 48kHz as a "clock" used in the dual-slope conversion process. This provides about three readings per second. (See *Nuts & Volts*, March '98, "Build the Elenco $20.00 Digital Multimeter Kit," for a more complete explanation of the dual-slope conversion process.)

Capacitors C2, C3, C4, C5, and resistor R11 are external components required for proper IC1 operation. Pin 1 of IC1 receives a regulated +5V from a 9V DC battery or power supply feeding VR1, an LM7805 voltage regulator, together with filtering capacitors C8 and C9, with IC1 pin 21 as the ground return.

The voltage at pin 36 compared to the voltage at pin 35 of IC1 determines the scale at which IC1 measures input voltage. This is determined by the setting of multi-turn potentiometer R8, fed by resistor R9 from the regulated +5 volt supply, as you'll see during "Calibration."

Two input voltages are provided to IC1 at pins 30 and 31. One is stable, the other varies with temperature, and IC1 measures this difference and converts this measurement to light the appropriate digital numbers on the display.

The voltage fed to IN LO pin 30 of IC1 comes from the pin 6 output of IC3, an LM301 operational amplifier eight-pin integrated circuit. IC4, an LM336 2.5-volt zener diode is fed from the 9V supply through resistor R1. Its zener action provides 2.5 volts to pin 3 of IC3. However, the other input of IC3, pin 2 is adjusted (as you'll see during "Calibration") by means of multi-turn potentiometer R3, R2, and feedback resistor R4, to provide a specific stable IC3 output voltage to pin 30 of IC1. We'll call this Voltage A. This voltage sets the temperature range to be read.

The voltage fed to IN HI pin 31 of IC1 comes from a network composed of resistors R5 and R10, multi-turn potentiometer R6, and adjustable temperature sensor IC5, an LM335.

IC5 is shown in Figure 4. This three-pin temperature sensor looks like a transistor, but is actually an integrated circuit with 16 transistors, two capacitors, and 10 resistors! The voltage across its output is adjustable by the voltage seen at the ADJ pin. Once adjusted, the positive terminal then increases in 10-millivolt (0.01 volt) increments with each positive

K-038 Digital Thermometer Parts List

All resistors 1/4-watt 5% carbon
R1, R5, R9 - 5.6K
R2 - 8.2K
R3, R8 - 10-turn 5K potentiometers
R4 - 1K
R6 - 10-turn 50K potentiometer
R7 - 100K
R10 - 1 megohm
R11 - 470K
R12, R13, R14, R15 - 470-ohm

Capacitors are 50V ceramic disc unless otherwise specified
C1 - 100pF
C2, C8 - 0.1mF
C3 - 0.01mF
C4, C6 - 0.047mF
C5 - 0.22mF
C7 - 10mF 25V electrolytic
C9 - 1mF 25V electrolytic or tantalum
C10 - 47pF
D1, D2 - 1N4148 signal diode
D3, D4 - Red 5mm round LED
D5 - Yellow flat LED
IC1 - ICL7107CPL 3-1/2 digit A/D converter
IC2 - CD4049B hex inverter
IC3 - LM301 operational amplifier
IC4 - LM336 2.5-volt zener diode
IC5 - LM335 temperature sensor
VR1 - LM7805 5-volt regulator
DISP1,2,3,4 - .56-inch 7-segment high-efficiency red common-anode display (MAN6960 or equivalent)
S1 - SPST slide switch
Miscellaneous: Printed circuit board etched, drilled, and silk-screened; nine-volt battery snap; three IC sockets (eight-pin, 16-pin, and 40-pin); hookup wires; solder.

Optional parts for Fahrenheit conversion:
R16 - 2.2K
R17 - 10K
R3 - 50K multi-turn potentiometer

Source

A complete kit of all parts above (possibly even including the optional parts by the time you read this) is available as the CEKIT K-038 Digital Thermometer Kit from **Centerpointe Electronics, Inc.**, 5241 Lincoln Avenue, Suite A6, Cypress, CA 90630. The price $37.95 plus $5.00 shipping and handling. California residents add 7.75% sales tax. Phones: **(800) 272-2737** or **(714) 821-1100**. Fax: **(714) 828-0282**. Call or fax for their FREE 14-page Educational Electronic Kits Catalog. Internet: **http://www.cpcares.com**.

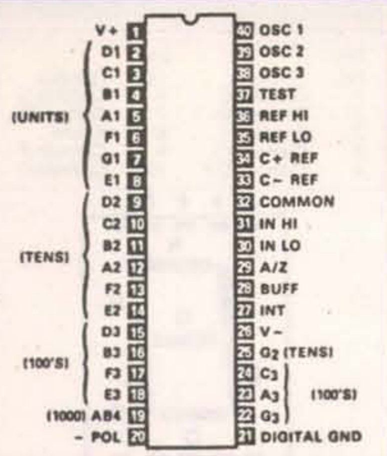


Figure 3: ICP7107CPL 3-1/2 Digit A/D Converter Pinout

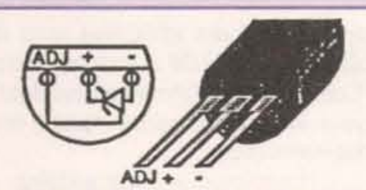


Figure 4: LM335 Temperature Sensor Pinout

change of one degree Centigrade.

The incoming nine volts is adjusted by R6 (during "Calibration") so the voltage provided by the sensor at the intersection of R6 and R10 reflects the actual temperature of IC5. We'll call this intersection Voltage B.

The difference between Voltage A (stable) and Voltage B (sensor temperature) provides the analog input to IC1, which then converts this analog voltage to a digital display readout.

Figure 5 is a pinout of the common-anode seven-segment LED display. Each display is connected to positive 5V, with each segment of each display "seeking" ground. The output of IC1, by providing a path to ground, determines which segments of each display are lighted, and therefore the number displayed.

Resistor R14 provides a path to ground for the decimal point of the second display, so that the maximum displayed number is 99.9. If that number is exceeded, pin 19 of IC1 provides a path to ground to red LED D3 and dropping resistor R12, lighting D3 for an "Out of Range" indication. If the display reads below 00.0, then polarity pin 20 of IC1 provides a ground path for yellow flat LED D5 and dropping resistor R13, lighting D5 to indicate a negative sign. LED D4 and dropping resistor R15 simulate a degree symbol.

Construction

As mentioned earlier, some of the parts required for this project may be difficult to find, or expensive. Although you could build this project from the information provided, we will assume you are assembling the K-038 from the kit described under "Source."

The printed circuit board layout is shown in Figure 6, and the parts layout using this board is shown in Figure 7. A total of 10 jumpers are used, and there are almost 200 solder connections!

Use special care in orienting polarity-sensitive parts (like diodes, LEDs, electrolytic capacitors), and properly orienting the integrated circuits in their sockets or solder locations. Also be certain to get the proper resistor and potentiometer values in the proper locations or later calibration will be impossible.

You must decide if you will be using the K-038 strictly as an environmental thermometer, or to measure the temperature of fluids or other "off board" items. If you are going to measure off-board, you will need to make a temperature "probe" by connecting the three leads of IC5, the temperature sensor, through a three-lead cable to the proper pads on the printed circuit board. The sensor can be mounted sticking out of a simple tube (we used the front end of a plastic ball-point pen barrel). Fill the tube with epoxy for insulation between leads when placed in fluids.

You might also give thought to packaging (discussed later) in which case, you might wish to mount the power switch, S1, off the board. The voltage regulator, VR1, gets pretty hot in extended operation, and you might want to add a heatsink to the tab, bearing in mind that the tab is connected internally to the GROUND pin of VR1.

Quick Test

When a 9V battery is connected, and switch S1 is turned on, all the displays and LED D4 should light up, as well as the decimal point of the center display. To make sure all segments of each of the three displays are connected, briefly connect +5 volts (NOT +9 volts!!) to TEST pin 37 of IC1. This should light all segments, showing 88.8. If not, refer to "Troubleshooting."

Don't be alarmed if the reading does not seem to be correct. The K-038 needs calibration.

Calibration

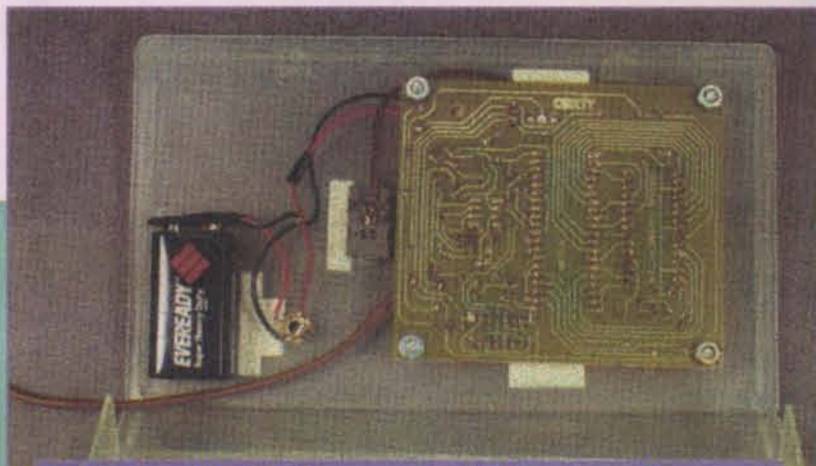
In order for the K-038 to have the proper range and "track" temperature properly, it is necessary to adjust the three potentiometers. R8 is adjusted so that exactly one volt, measured with a digital voltmeter, appears between pin 36 (positive voltmeter lead) and pin 35 (common voltmeter lead) of IC1. This sets the analog input voltage range of IC1 from 0 to 2 volts, allowing a range of 200 degrees at a sensor input of 0.01 volts per degree. This is beyond the range needed for reading -40.0 to +99.9 degrees Centigrade.

The next adjustment is made to R3, which is set to read exactly 2.73 volts between output pin 6 and ground pin 4 of IC3, the LM301 operational amplifier. This sets Voltage A (pin 30 of IC1) so that when Voltage A and Voltage B are identical, the display will read 00.0.

The final adjustment is made to R6, and this depends on knowing the actual sensor temperature. If, for example, the sensor is at a room temperature of 22 degrees Centigrade, simply adjust R8 until the display reads 22.0. If the sensor is in a liquid that has a known Centigrade temperature, use that figure for setting R6. In any case, the voltage at the intersection of R6 and R10 (Voltage B) will be higher or lower than pin 30 (Voltage A) by 0.01 volts per degree Centigrade difference between the sensor temperature and 0 degrees Centigrade.

To aid you in converting from Centigrade to Fahrenheit temperatures, see Table 1. The formulas for

The K-038 was packaged in an empty translucent plastic case from a video cassette, and labelled using a computer desktop publishing program.



The circuit board, power switch, external power jack, and battery are all mounted to the case lid.

conversion are:

Fahrenheit Degrees =
(1.8 times Centigrade Degrees) + 32
Centigrade Degrees =
(Fahrenheit Degrees - 32) times .5555

Troubleshooting

If the displays don't come on when you apply power, check for approximately +9V DC at the input pin of VR1 (right pin looking down on PC board with displays at the top of the board) and +5V DC at the output (left) pin. The center pin and metal tab are ground.

Once you have power, the displays should come on. Connect +5V briefly to TEST pin 37 of IC1 to assure that all segments (but not all decimal points) light. Looking at Figure 5, you'll see how the segments are identified (A-G). The schematic (Figure 2 and Figure 3) shows you which pins on IC1 drive each segment of each display. If a segment doesn't light during TEST, check the solder connections at IC1 and the display.

Any other problems can probably be traced to a bad solder joint, an incorrect part location, improper orientation of a polarity-sensitive part, or an IC plugged in "backwards." Troubleshooting is more of an art than a science, and takes patience, as well as thought.

Modifications

As this is being written, the manufacturer of the K-038 kit is planning to modify the circuit board and provide the additional parts to allow you to build the kit for either Centigrade or Fahrenheit readout. If your kit has this option, follow the kit instructions.

However, if you are building from scratch with the circuit and PC board shown, then there are only some small changes needed. For one thing, since your displays will now read in full digits (-032 to +212 and beyond), the decimal point is no longer needed, so remove resistor R14.

Resistors R16 (2.2K) and R17 (10K) are added to the circuit as shown in Figure 8. This is most easily done at the bottom of the printed circuit board.

Remove Jumper 7, noting the top and bottom solder pads from which it is removed. Now solder one end of R16 to the pin 3 pad of IC3. Solder one end of R17 to the bottom pad from which Jumper 7 was removed. Next, connect the free ends of R16 and R17 to the top

Pin No.	Function	Pin No.	Function
1	Cathode E	6	Cathode B
2	Cathode D	7	Cathode A
3	Anode	8	Anode
4	Cathode C	9	Cathode F
5	Cathode D,P	10.	Cathode G

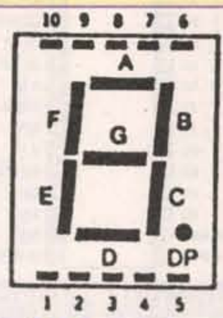


Figure 5: Seven-Segment Display Pinout

°C	°F	°C	°F	°C	°F	°C	°F
100	212.0	63	145.4	26	78.8	-11	12.2
99	210.2	62	143.6	25	77.0	-12	10.4
98	208.4	61	141.8	24	75.2	-13	8.6
97	206.6	60	140.0	23	73.4	-14	6.8
96	204.8	59	138.2	22	71.6	-15	5.0
95	203.0	58	136.4	21	69.8	-16	3.2
94	201.2	57	134.6	20	68.0	-17	1.4
93	199.4	56	132.8	19	66.2	-18	-0.4
92	197.6	55	131.0	18	64.4	-19	-2.2
91	195.8	54	129.2	17	62.6	-20	-4.0
90	194.0	53	127.4	16	60.8	-21	-5.8
89	192.2	52	125.6	15	59.0	-22	-7.6
88	190.4	51	123.8	14	57.2	-23	-9.4
87	188.6	50	122.0	13	55.4	-24	-11.2
86	186.8	49	120.2	12	53.6	-25	-13.0
85	185.0	48	118.4	11	51.8	-26	-14.8
84	183.2	47	116.6	10	50.0	-27	-16.6
83	181.4	46	114.8	9	48.2	-28	-18.4
82	179.6	45	113.0	8	46.4	-29	-20.2
81	177.8	44	111.2	7	44.6	-30	-22.0
80	176.0	43	109.4	6	42.8	-31	-23.8
79	174.2	42	107.6	5	41.0	-32	-25.6
78	172.4	41	105.8	4	39.2	-33	-27.4
77	170.6	40	104.0	3	37.4	-34	-29.2
76	168.8	39	102.2	2	35.6	-35	-31.0
75	167.0	38	100.4	1	33.8	-36	-32.8
74	165.2	37	98.6	0	32.0	-37	-34.6
73	163.4	36	96.8	-1	30.2	-38	-36.4
72	161.6	35	95.0	-2	28.4	-39	-38.2
71	159.8	34	93.2	-3	26.6	-40	-40.0
70	158.0	33	91.4	-4	24.8		
69	156.2	32	89.6	-5	23.0		
68	154.4	31	87.8	-6	21.2		
67	152.6	30	86.0	-7	19.4		
66	150.8	29	84.2	-8	17.6		
65	149.0	28	82.4	-9	15.8		
64	147.2	27	80.6	-10	14.0		

Table 1: Temperature Conversion Chart

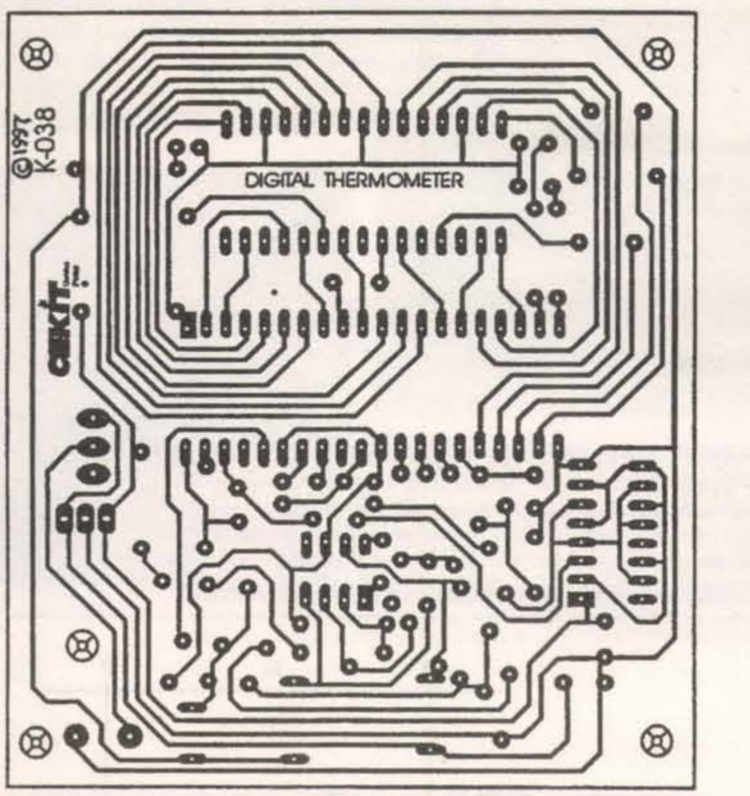


Figure 6: K-038 Printed Circuit Board Layout

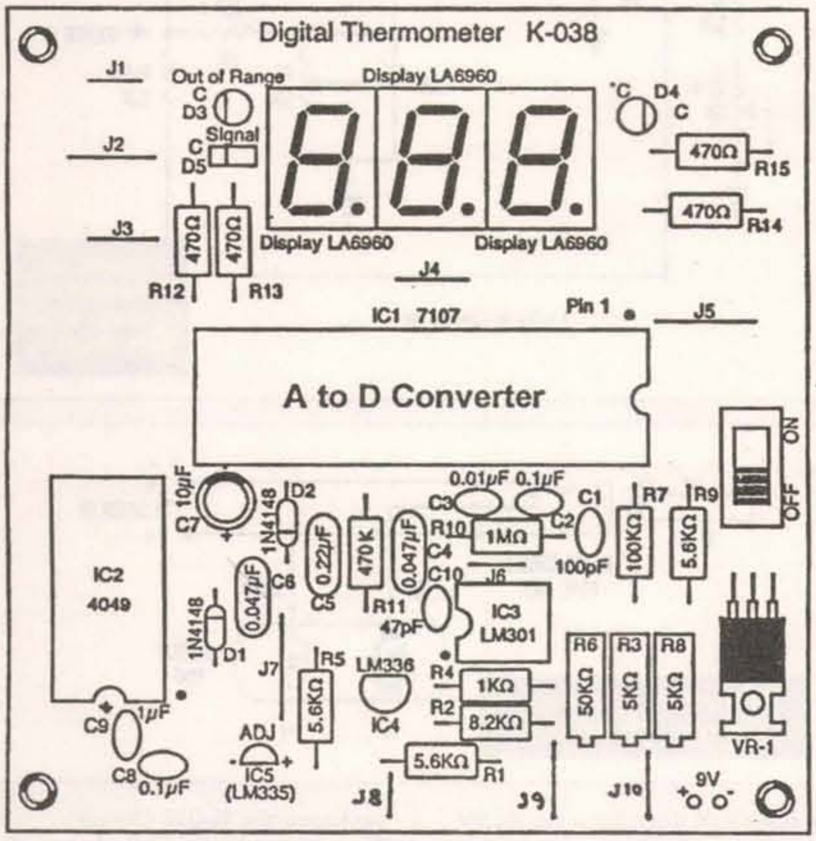


Figure 7: K-038 Parts Layout

point where Jumper 7 was removed. Note that Voltage B is now at the intersection of R10, R16, and R17.

One other change is required. Unsolder 5K potentiometer R3 and replace it with a 50K multi-turn potentiometer. This completes the changes, but now you must recalibrate. Set potentiometer R8, as before, to one volt between pins 36 (positive) and 35. This allows an analog input voltage range of zero to two volts, the same as with Centigrade readings.

Set the replaced potentiometer R3 to a new voltage of 2.554 volts from output pin 6 and ground pin 4 of IC3, the LM301 operational amplifier. This sets Voltage A (pin 30 of IC1) so that when Voltage A and Voltage B are identical, the display will read 000. With the new resistor network connected to IC5, the Voltage A to Voltage B difference is one millivolt (0.001 volts) for each one degree Fahrenheit change in sensor temperature.

Now adjust potentiometer R6 so the display reads the actual sensor Fahrenheit temperature, and you are finished with the conversion.

When operated on battery power, the K-038 uses about 200 millamperes, which is well beyond

Continued from page 32

engine speed for 60N. It should read from 50 CPM to 65 CPM.

A dirt cheap and simple way to measure the frequency output of your engine-driven generator is to use a clock! Yes, a clock! Older style clocks used a synchronous motor that relied on the 60 Hz stability of the power line to determine time.

It is important to use a motor driven clock, preferably with a sweep second hand. Adjust the speed of the engine up or down to make a "minute" of indicated clock time equal to a true minute, as determined say by your wristwatch.

Michael Mruzek
via Internet

ANSWERS TO #6996 - JUNE 1999

According to a dairy farmer friend who owns a PTO-driven generator, measuring generator speed is done with the instrumentation already on the tractor and generator.

Since the PTO is connected to the engine through a fixed-ratio gear reducer, the engine's tachometer will indicate PTO speed after dividing the reading by the gearbox ratio.

Some tractor tachometers have the PTO speed already on them as a secondary calibration, much like car speedometers that are calibrated for MPH and KPH. Also, PTO-driven generators almost always have a frequency meter as part of their instrument set.

When running the generator, my farmer friend relies on this instead of the tractor's tachometer.

If you don't have either of these instruments, you have a few options. The first — and perhaps the simplest — would be to install a tach on the tractor. Find out the gear ratio between the engine and the PTO, then divide the tach reading by this ratio to get the PTO speed.

Since almost all implements, including generators, are designed for a PTO speed of 540 RPM, just open up the throttle to a speed just a little faster, then apply the load to the generator. You can find your PTO gearbox ratio by inspection — crank the engine by hand (does yours have a hand starter on the front?) and count. How many turns the engine makes for one turn of the PTO.

If you don't want to or can't install a tach, you have several low-cost options. The first is to build a frequency meter. Install several magnets on the PTO shaft and a Hall sensor to measure PTO rotation. Feed that signal to a frequency-to-voltage converter such as a one-shot, a dedicated V-F chip, or a PLL, then connect the output of that circuit to an indicator such as a bargraph or a meter.

Another method would be to monitor the output of the generator with a frequency counter. Use a step-down transformer to both reduce the voltage of the signal and to provide isolation. A simple bell transformer would do. Finally, check with Fair Radio Sales www.fairradio.com to see if they have any surplus vibrating reed frequency meters.

These were used extensively by the military because they were rugged and reliable. They fell out of favor largely because they became much more expensive to manufacture than modern electronic indicators.

As a final word, check the generator carefully prior to using it on a critical or expensive load. Make sure it keeps its output voltage within a reasonable range under full, partial, and no-load conditions, and check that it is properly fused and grounded.

David B. Sarraf
via Internet

ANSWER TO #7992 - JULY 1999

I need information on building a variable frequency drive for a single phase motor. I would like to build one to adjust the speed on a wood turning lathe.

Single phase motors are wound for a given frequency, due to their impedance. Altering the frequency will overheat the windings. What you want is one of two methods of altering the voltage while keeping the current the same.

One method is to use a "auto transformer" commonly referred to as a "variac."

The other method uses a "chopper" which is used readily as a "light dimmer."

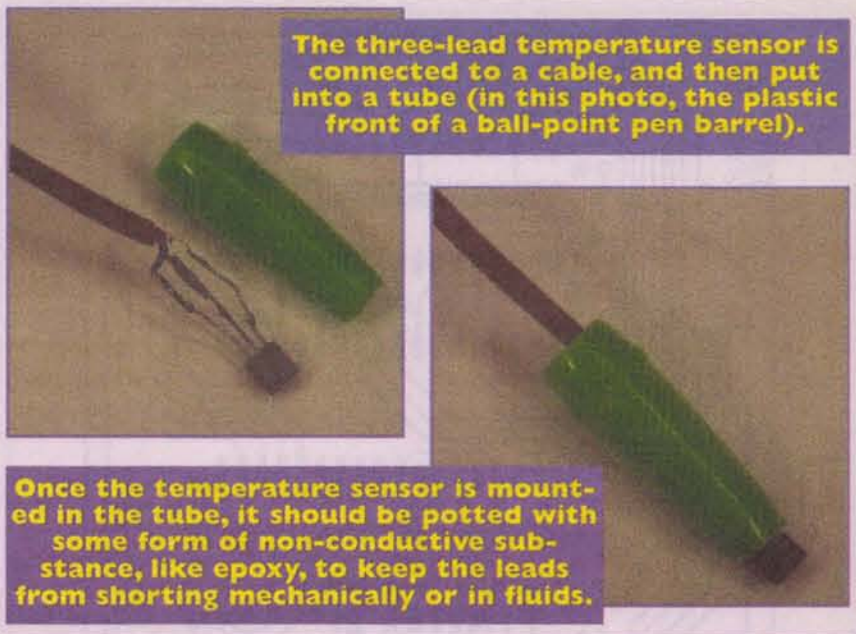
The light dimmer is sold at most hardware stores for around $5.00 and it works quite well, but it has some flaws. As you lower the voltage very low on a motor, the "chopped" pulses are noticeable on the lathe and cause pulsing in the motor which can affect the finish of the cut. At medium to high speed, there is no noticeable pulsing.

The other method — the Variac — is the best and most reliable method of total control over a motor's speed. It consists of two transformers in one that move in relationship to each other keeping the current totally constant while lowering the output side of the secondary transformer in voltage only.

This method not only has zero pulsing, but it is electronically quieter in terms of radio noise. I prefer the transformer over the chopper, but either works well.

A 600 watt variac sells for around $20.00 to $40.00 used, while a new one can cost any where from $50.00 to over $100.00. The chopper sells for $5.00 and that is always a consideration.

Chris
Bieber, CA



The three-lead temperature sensor is connected to a cable, and then put into a tube (in this photo, the plastic front of a ball-point pen barrel).

Once the temperature sensor is mounted in the tube, it should be potted with some form of non-conductive substance, like epoxy, to keep the leads from shorting mechanically or in fluids.

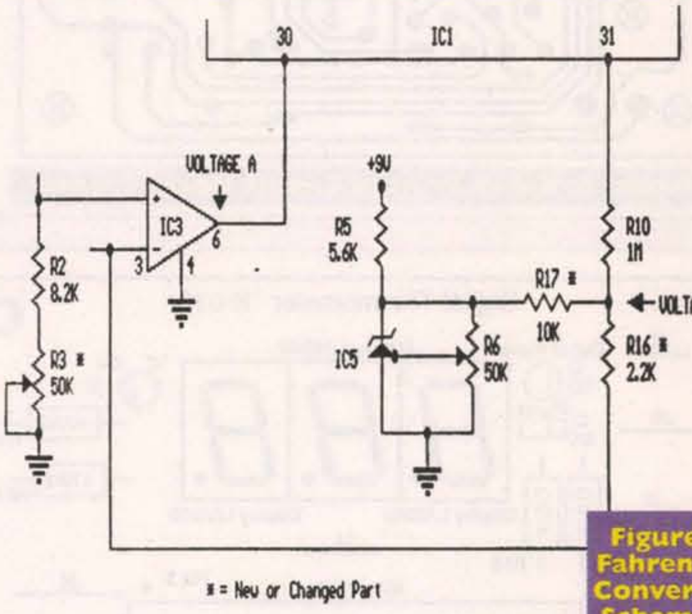


Figure 8: Fahrenheit Conversion Schematic

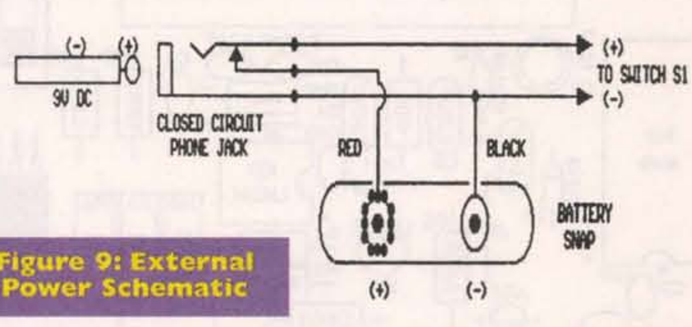


Figure 9: External Power Schematic

the suggested drain for a typical 9V radio battery. As soon as the voltage drops below about seven volts, the K-038 readings become erratic. If you wish to add the capability of powering the K-038 externally, any common wall-plug transformer DC power supply can be used, as long as it supplies about nine volts at 250 milliamperes or more.

Figure 9 shows how a standard closed-circuit phone jack can be wired to disconnect the battery when external power is used. If you use external power, be certain it is DC, and that the polarity of the external power is proper.

Packaging

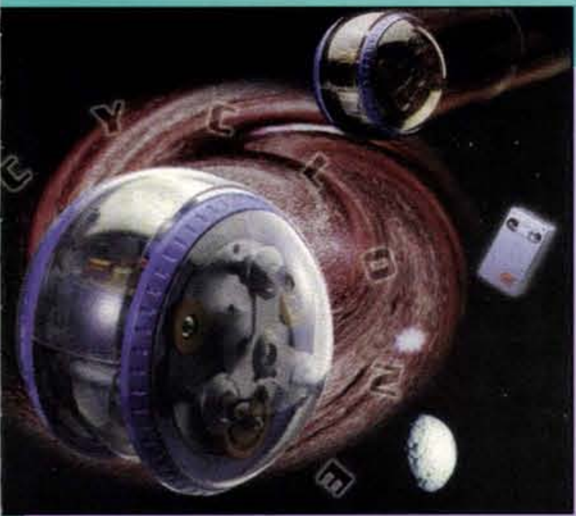
As shown in the photos, we packaged the K-038 Digital Thermometer in an empty translucent case designed to hold a video cassette. Since it was made of thin plastic, it was relatively easy to cut access holes and a "window" to view the digital display.

The printed circuit board was mounted display-up in the cover of the case using four screws and nuts. The switch and external power jack were also mounted on the cover, and the battery was held inside the cover with double-sided tape.

The sensor cable and probe come out through a notch in the bottom of the case.

Labels were made using a desktop publishing computer program, and pasted to the cover. **NV**

New Product News



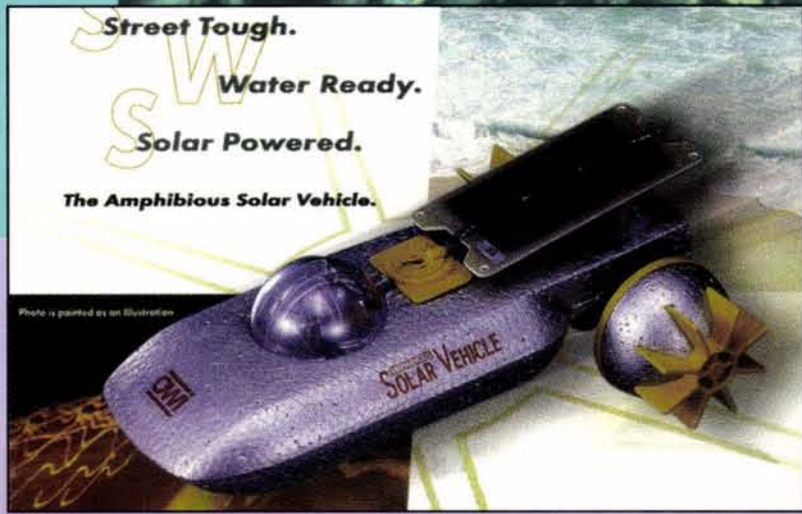
CYCLONE ROBOT KIT

Powered by a wireless remote radio controller, Cyclone responds instantly to commands of 'spin,' 'swivel,' 'forward,' 'backward,' 'left,' or 'right.' Six different frequency settings offer a multitude of challenges, including speed races or timed, maze competitions. Control sticks afford the user complete control even as Cyclone swivels wildly from left to right.

Cyclone possesses a certain mystery and stands apart from other MOVIT family members. Its unique design includes domes that protrude from the sides of two parallel wheels and see-through membrane that permits interior viewing to engage the eye. Engineers also will be intrigued by: a motion system based upon drive wheels and concentric discs that allow the user to propel its movement and, a ballast created by the batteries' weight to keep Cyclone's center upright.

Cyclone provides basic knowledge of wireless remote controllers and principles of gear mechanism.

Suggested retail price: $74.95.



AMPHIBIOUS SOLAR VEHICLE

This kit teaches and introduces the fundamentals of solar power through hands-on experiments. The sun or any intense mobile light can power the solar battery. The multiple function switch (solar or battery) allows this kit to be energized day or night, indoors or outdoors.

Its scientifically structured catamaran design reduces water resistance and makes capsizing more difficult.

The user can explore different types of energy and energy conversion with this land and water vehicle.

Discover the world of alternative evergy by learning what materials solar batteries are made from, characteristics of solar batteries, advantages and disadvantages of solar.

Suggested selling price: $39.95.

For more information, contact:

OWI, INC.OWI, INC.
17141 KINGSVIEW AVE., DEPT. NV
CARSON, CA 90746
310-515-1900 FAX: 310-515-1606
E-MAIL: owi@ix.netcom.com
WEB: http://owi-inc.com http://owirobot.com

IC-T81A TRANSCEIVER

Icom America announces their newest handheld, the IC-T81A. This radio has it all with four bands, excellent audio, 124-memory channels, water resistant construction, and Icom durability.

The IC-T81A is only 2.3" in width by 4.2" in height and 1.1" thick, weighing only 9.9 oz. This slim, yet powerful radio covers the 6M, 2M, and 400 MHz at 5 watts output power and 1 watt on the 1.2 GHz band.

The IC-T81A boasts a five-position "joy stick" control for easy control of set mode, tone, duplex, volume, operating band, scanning and more, as well as an alphanumeric display for memory channel naming.

For more information, contact:

ICOM AMERICA, INC.
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BELLEVUE, WA 98004
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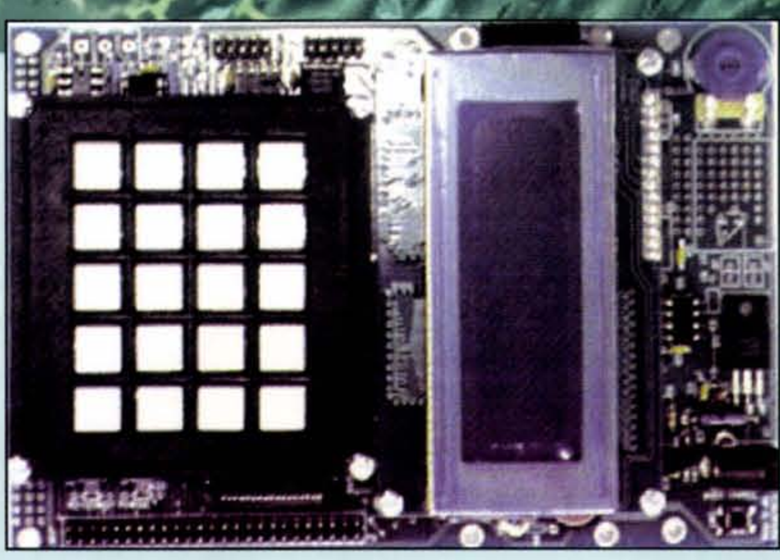

CP-550 HIGH-SPEED 8051 CARD

The CP-550 is a high-speed 8051 card featuring an optional LCD display and keypad. It uses the recently introduced 87C550 MPU.

The LCD display option supports two configurations: two lines of 20 characters, or four lines of 20 characters.

The microcontroller used on the CP-550 is the 87C550, which is an enhanced 8051 family derivative. It offers an eight-channel, 10-bit A/D converter, 8K bytes of on-chip EPROM, 1K bytes of on-chip SRAM, PWM outputs, up to 55 digital I/O lines, optimized instruction execution, up to 33 MHz clock speed, two full-duplex serial ports, dual data pointers, power-fail reset, watchdog timer, 16 interrupt sources, and enhanced STOP and IDLE operations.

Other board features include RS-232 buffering on serial port 0, optional RS-232 or RS-485 buffering on serial port 1, and optional DS1286 calendar/clock chip.

The CP-550 comes with system monitor debugger software installed in the 87C550's EPROM. During development, this debugger allows user code to be downloaded in two battery-backed RAM, and then tested. Once tested, user software can be burned into the available board EPROM.

For more information, contact:

ALLEN SYSTEMS
2346 BRANDON RD., DEPT. NV
COLUMBUS, OH 43221
614-488-7122
E-MAIL: allensys@aol.com
WEB: http://members.aol.com/allensys

BA-1 BALUN BOX

LDG Electronics announces the introduction of the BA-1 Balun Box.

The 4:1 BA-1 provides an easy interface of ladder line and long-wire antennas to radio transceivers requiring an output impedance of 50 to 75 ohms.

This device is also the perfect compliment to the AT-11, microprocessor controlled automatic antenna tuner.

The BA-1 is sold in kit and assembled form. The kit assembles in about 20 minutes and requires only minimal soldering skills. The BA-1 ships with an enclosure so there is nothing else required to complete the kit. The finished kit measures only 4.7 in. x 6.1 in. x 1.2 in. and weighs only 6 oz. Frequency coverage is 1.8 to 30 MHz and peak input power is 200 watts.

The BA-1 Balun kit retails for $25.00 plus shipping. The assembled BA-1 retails for $30.00.

For more information, contact:

LDG ELECTRONICS, INC.
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